SUSTAINABLE DEVELOPMENT OF THE NILE RIVER

AT

GREATER KHARTOUM

ELTAYEB IBRAHIM ELMADIH IBRAHIM

A thesis submitted to the University of Huddersfield

in partial fulfillment of the requirements for

the degree of Doctor of Philosophy

November 2011

List of Contents

Total Chapter Words including Tables (5498)

List of Tables

List of Illustrations

List of Photos

Appendices

Bibliography

Acknowledgement

I can not begin to thank my small or extended family for their tremendous assistance and absolute support. Although the PhD research is an individual contribution to knowledge, but many others contributed and assisted. In this research numerous people have been shared and consulted, and without diminishing the contribution and the role of any of them, some of them need to be mentioned.

Special note of thanks and acknowledgements to my director of studies Richard Fellows. From my first visit to UK before my official enrolment in the University of Huddersfield and until today he is continuously encourage, cooperate and assist me. He play a significant role in the performance of this thesis by his useful recommendations, comments, guidance and supports to me either by emails or directly within my annual visit to UK which extended for more than five years. Particular thanks and acknowledgements are also directed to my supervisor Richard Nicholls who put my research on the right track. It is referred to him the improvement and development of this research due to his useful emails, selection of suitable references and his direct comments within my annual visit to UK.

I cannot forget to thanks and acknowledge the great wisdom man in the University of Huddersfield, who always help and support all students' particularly overseas ones, that is Dr Ian Pitchford.

Also I would like to thank my local supervisor Dr Saief Sadig in the University of Khartoum in Sudan who assist me within the various stages of the research.

My great thanks and acknowledgement is stretched to the staff in the School of Design and Architecture in the University of Huddersfield.

In addition, gratitude is sent to the following local persons and companies:

- University of Khartoum Faculty of Architecture.
- UNESCO Chair in Water Resources in Sudan
- Ministry of Irrigation in Sudan.
- Sudan Meteorological Authority in Sudan.
- Ministry of Planning in Sudan.
- University of Cairo in Egypt.
-

Copyright Statement

i. Research Degree Thesis: Format, Submission and Examination. The author of this thesis (including any appendices and/or schedules to this thesis) owns any copyright in it (the "Copyright") and s/he has given The University of Huddersfield the right to use such Copyright for any administrative, promotional, educational, and/or teaching purposes.

ii. Copies of this thesis, either in full or in extracts, may be made only in accordance with the regulations of the University Library. Details of these regulations may be obtained from the librarian. This page must form part of any such copies made.

iii. The ownership of any patents, designs, trademarks and any and all other intellectual property rights except for the Copyright (the "Intellectual Property Rights") and any reproductions of copyright works, for example graphs and tables ("Reproductions"), which may be described in this thesis, may not be owned by the author and may be owned by third parties. Such Intellectual Property Rights and Reproductions cannot and must not be made available for use without the prior written permission of the owner(s) of the relevant Intellectual Property Rights and/or Reproductions.

Abstract

Sudan is the largest country in Africa, but there is poverty and a lack of infrastructure, skills and opportunity despite its substantial natural resources. The capital of Sudan is Khartoum City, located at the confluence of the Blue and White Nile Rivers. Unfortunately development on Nile River Front is limited due to the risk of flooding and erosion. There is a danger that rapid economic development may take place in this unique area without sustainable development planning. This research project aims to develop strategies to protect the Nile River banks by suitable stabilization methods so that development can take place safely.

Data has been collected about hydrology, morphology, geotechnical factors, soil classifications, river pattern systems, driving forces, and the main problems restricting sustainable development and engineering works for the Nile River. In addition the following have been reviewed: historical background, existing land uses, current environmental situations, and the economic and social conditions of the study areas. Research identified Cairo, Egypt as a similar case study, where data collected by the author included historical background, current situations, strategic visions and development plan for Nile River Shores. Further information was collected about sustainable development from a general literature review.

From these collected data a set of guidelines and indicators for sustainable development was established related to environmental, economic and social factors. Based on those guidelines and indicators, methods of stabilization of the banks for each shore were specified and a proposed development plan was established. Methods of stabilization of banks and the development plan were refined and evaluated to establish a final version of the development plan: Sustainable Development of the Nile River Front (SDNRF) at Greater Khartoum. From refinement and evaluations, barriers and constraints for implementation were specified with their suggested solutions. Finally, conclusions and recommendations related to the SDNRF Manual about development and regulations were established.

CHAPTER ONE: RESEARCH METHODOLOGY

1:0 Introduction

This Thesis will describe the carrying out and results of a PhD research project for study to investigate the options for the sustainable development of the Nile River Front at Greater Khartoum.

This chapter will introduce the research project by identifying the problem under consideration and explaining the method by which it will be investigated and solutions proposed. It will also explain the structure of the thesis. Finally it will detail the expected new contribution to knowledge.

1:1 General Introduction about the Study Area

The republic of Sudan is the largest country in Africa and is located in the North Eastern part of this continent. It is bordered by Egypt, the Red Sea, Eritrea, Ethiopia, Kenya, Uganda, the Democratic Republic of Congo, the Central African Republic, Chad and Libya running clockwise from the North respectively. The capital city of Sudan is Greater Khartoum. Greater Khartoum is composed of three cities: Khartoum, Omdurman, and Khartoum North. It has a unique location at the confluence of the Blue and White Niles. These two rivers join to form the River Nile proper which has its origin at Khartoum.

In recent years Sudan has experienced rapid economic growth due to its natural resources such as oil reserves. Development is associated with environmental damage either through its use of materials, energy, the displacement of existing biodiversity or its strain on the local infrastructure. Recent years has seen rapid and widespread development in many previously un-developed countries. There are now proposals to develop the Nile River Front area at Khartoum. This PhD research project aims to look at the potential impact of development on this area and by looking at other examples of sustainable development to suggest ways in which the environmental impact of this proposed development can be reduced. The focus will be on shore protection and riverbank development.

The total length of the water front to be included in the study area is 67.875 km of the three rivers within Greater Khartoum with six water front's areas. Only small areas of the waterfront

within Greater Khartoum city centre are provided with defences which offer varying standards of protection against shoreline erosion or flooding. Outside the city centre, the riverbank is generally undefended. These locations also tend to coincide with areas of high potential i.e. recreational, landscape of importance or areas of interest for their economic importance, particularly in terms of building development. The undefended lengths of the three rivers play their part in the formation of the proposed changes to the waterfront. Because the banks of the three rivers are composed of alluvial soil, they are prone to erosion and are capable of releasing significant quantities of material which is then deposited within the local sediment system.

The area adjacent to the Greater Khartoum waterfront is of high landscape quality and outstanding natural beauty. These areas are rural in character, although they also encompass thriving communities and businesses and are valued for their recreational facilities. To date there has been no major development within the flood plain and the adjacent areas. Such development as has occurred has generally been small scale residential infill made by local communities. No major river works have been carried out on the river front since defences were constructed subsequent to a major flood in 1946. The contention that the Greater Khartoum river front is not being sustainably developed is related to the fact that management of the river front is not being undertaken within a strategic appraisal and implementation framework and is without consideration of the pertinent factors. These factors relate to environmental (in particular river morphology and flooding) and economic issues.

This study will identify and quantify critical factors for the success of developing Nile River Front at Greater Khartoum by stabilizing river banks for safely sustainable development. This can be obtained by examining various environmental, social, economical, architectural and urban design precedents and to devise a comprehensive implementation framework for Sustainable Development of the Nile River Front SDNRF at Greater Khartoum.

1:2 Statement of the Problem

The Nile River is a meandering river. The Nile River in Greater Khartoum has six frontages as specified below:

- The Blue Nile is facing Khartoum and Khartoum North with the length of 23.250 km for the both sides of the river in the study area.
- The White Nile is facing Khartoum and Omdurman with the length of 24.5 km for the both sides of the river in the study area.
- The Main Nile is facing Omdurman and Khartoum North with the length of 9.750 km for the both sides of the river in the study area.

The main problem that restricted the development of the Nile River Front in Greater Khartoum is flooding of the Nile River during flood season. The annual flood of the Nile River is affected by the hydrology of the Blue Nile, where the discharge flow of the Blue Nile is 700,000,000 m^3/day in flood season and 10,000,000 m^3/day in dry season. This hydrological situation of the Blue Nile has direct impact on the hydrology of the White Nile where it is of annual stable discharge flow of 73,000,000 m^3/day and the Main Nile River. The flood of the Nile River occurs when the water level reached its maximum level in flood season which is 380.88 meter above sea level, while in dry season is 373.06 meter above sea level as minimum level. The variation of water level represents the average hydrological parameters for sustainable stabilization banks of the Nile River. The high variation of water level between flood and dry season causes mudslides problems in the study area. The mudslides occurred on the eroded sides of the Nile River in a form of failure as beam at the bank of sand layer area and sliding failure.

Flooding of the Nile River during flood season or inundation period restricted the development of the Nile River Shores at Greater Khartoum. This research will tackle the hydrology and the Nile River pattern system in Greater Khartoum to establish guidelines for methods of river stabilization banks and safely development of the Nile River Shores. This will be in a comprehensive framework or development plan for sustainable development of the Nile River Front in Greater Khartoum.

1:3 Statement on the scope of the Thesis

The scope of this thesis is to understand the general characteristics of the Nile River Banks and their adjacent Shores to formulate scientific planning policies to establish comprehensive framework for sustainable development plan for Nile Riverfront in Greater Khartoum. The chosen of river banks and their adjacent shores in this study for the following reasons:-

- Unique of the study area that no similar to it in the world as it is located on the confluences of the Blue and White Nile that merge the River Nile the longest river in the world with six frontages shores.

- This unique area of the Nile Riverfront is the most valuable area in Greater Khartoum and even in the whole world due to its natural characteristics.
- This unique area no scientific studies have been taken to tackle it, therefore this first study will act as a base for other coming studies
.
- There is rapid economic development that may take place in this valuable area without scientific sustainable development planning programmes since there is no sustainable development plan that can direct and control the development for this unique area in Greater Khartoum.

- The study will establish sustainable framework for developing Nile Riverfront in Greater Khartoum that elaborating guidelines for sustainable development for stabilizing banks and waterfront projects.

- The study will raise the important of sustainable development of the Nile Riverfront in national and local appraisal policies.

- The study will contribute in raising public awareness about sustainability by establishing environmental, social and economic indicators for developing Nile Riverfront in Greater Khartoum.

- The study will made a unique contribution to the world by establishing sustainable indicators for developing waterfront.

1:4 Aims of the Study

There are two main aims of this study as specified below:

1:4:1 Stabilization of the Nile River Banks

To suggest a strategy for the stabilization of the Nile River Banks in the most sustainable manner by identifying the factors that threatens the stability of the Nile River banks at Greater Khartoum and by ranking stabilization methods in terms of function and sustainability. The achievement of this aim will be met by:

- Studying the hydrology and morphology of the White, Blue and River Nile at Greater Khartoum.
- Identifying the flood zones and erosion areas along the banks of the three rivers.
- Ranking river stabilization methods in terms of sustainability.
- Developing a set of guidelines and indicators for sustainable stabilization river banks.
- Establishing suitable methods for stabilization of the river banks in the study area.

1:4:2 Sustainable Development of the Nile River Shores:

To establish sustainable development plan for developing the Nile River Shores at Greater Khartoum in a manner that has to due regard for sustainability and river pattern systems. The achievement of this aim will be obtained by:

- Collecting appropriate data about sustainable river front development appropriate to the study.

- Developing a set of guidelines and indicators for achieving sustainable development on the Nile River Front.
- Considering the three fundamental aspects of the sustainable development due to their environmental, social and economical factors.
- Proposing a development plan for the study area.
- Identifying barriers and constraints and proposing suggestions for overcoming these barriers

1:5 Research Hypotheses

There are a number of hypotheses that will be tested by this research project as specified below:

- That it is possible to survey existing conditions at the study area to act as a base line for future development of the Nile River Front at Greater Khartoum.
- That it is possible to propose river bank stabilization methods based on local ground and water conditions.
- That it is possible to research examples of river front developments to identify those relevant and irrelevant elements for sustainable development of the Nile River Front.
- That it is possible to study the theory of sustainable urban development and existing sustainable development assessment systems in order to identify those aspects associated with sustainable development of the Nile River Front.
- That it is possible to develop sustainable indicators for assessing river stabilization methods and urban development elements for the Nile River Front at Greater Khartoum.
- That it is possible to establish sustainable development strategy for SDNRF at Greater Khartoum for a sustainable development of the study area and establish guidelines for the main recommendations and legislation that are able to control and direct the development.

1:6 Research Method

The methodology employed by the research will be to carry out a combination of field study and literature research. The field study will generate new primary data relating to the existing conditions found along the riverbanks. While the literature study will identify the way in which the methods used to stabilize the river banks can be assessed for sustainability. It will also reveal the principles upon which the adjacent riverbank can be developed sustainably.
In particular the research methodology will involve:

- Collection of relevant base line data from existing public sources with regard to environmental, economic and social factors.
- Extensive literature review on previous research into sustainable urban development especially that related to developing countries and river fronts.
- Collection of relevant data from a similar or related case study.
- Generation of new primary data from site survey, river survey and general observations.
- Generation of sustainable indicators from collective data for planning process.
- Generation of new sustainable development issues from analysis and synthesis of the planning process.

The execution of the methodology will be carried out in stages. Stage one will involve data collection, stage two will develop a set of guidelines for sustainable development, stage three will tackle the plan making process, stage four will evaluate the development plan and stage five will develop a set of guidelines for implementing the recommendations. These stages are described more fully below:

1:7 Stage One: Data Collection

Types of primary and documentary data that are to be collected will be as specified below:

1:7:1 Collection and Collation of Existing Data related to the Study Area

The following data will be accessed, collected and assessed:

- Historical background about Nile River and study area.
- Data from engineering investigations about the hydrology, morphology, geotechnical, floodplains, erosions, mudslides, river banks, river shores, driving forces and general characteristics of the Blue, White and Main Nile River.
- Data about planning policies applicable to the study area.
- Maps, existing land-use plans for different areas within the study area such as agricultural, residential, commercial, industrial, and infrastructures.
- Existing planning policies, planning regulations, legislations, laws, building regulations.
- Data about current studies carried by Khartoum Central Business District Study Team and UNESCO Chairs in Water Resources in Sudan for the study area.

1:7:2 Data from Survey and Observations

This will be new primary data collected by the author within the following areas:

- Identification of discrete shores within the Nile system.
- Survey of current shore line length and activities.
- To organize and manage the research process.

- Photographic survey of the shore lines.
- Survey of the current environmental, social and economic situation.

1:7:3 Data collected from Cairo in Egypt

The selection of Cairo in Egypt as a case study is due to the similarities between Cairo and Khartoum. Data from Cairo will be a key issue for guiding the SDNRF at Greater Khartoum. The data collected from Greater Cairo will explore the different elements of river front development. Data from the Greater Cairo case study will include:

- Historical background about Greater Cairo.
- Current details of the Nile River Front at Greater Cairo.
- Environmental classification areas of the Nile River Front.
- Roles and values of the Nile River in environmental, economic and social factors for sustainable development at Greater Cairo.
- Data about proposed development plan for Nile River Shores at Greater Cairo.
- Data about Greenway System for Greater Cairo.
- Photographic record of the Cairo Nile river front.
- Data related to other Case Studies in the world.

1:8 Stage Two: Guidelines for Sustainable Development

In this stage the primary and secondary data collected in stage one will be developed to work out a set of guidelines for sustainable development. These guidelines composed of a set of main factors affecting stabilization of the Nile River Banks and the main indicators for sustainable development of the Nile River Front. These guidelines related to environmental, social and

economic factors. The environmental factors will tackle flooding, erosions, hydrology of the Nile River, lack of infrastructures and river forces. The economic factors restricting the sustainable development will tackle poverty, lack of economic opportunities, compensation value for lands ownership and lack of local materials. While social factors restricted the sustainable development will tackle lack of local skills, lack of public awareness about sustainability and lack of legislations.

The main indicators that measuring appropriate sustainable development of the Nile River related also to environment, economic and social indicators as specified below:

- Environmental indicators that measuring a degree of successfulness of sustainable development of the Nile river Front such as banks stabilization methods, traffic methods, accessibility to the river, flexibility of the development urban elements, greenway system, sky line of the Nile River and general improving of the environment.

- The economic indicators for measuring successful development such as increase in land value change in uses of lands and degree of contribution to local and national economy.

- While the social indicators such as satisfaction of population needs, improvement in social services and in health.

These sustainable indicators will be used in different planning process of the development plan for SDNRF at Greater Khartoum.

1:9 Stage Three: Plan Making Process

In this stage a development plan will be formulated based on the sustainable indicators. This plan will be used in developing suitable methods of stabilizing each of the Nile River Banks and to propose river stop stations that will be used in river traffic system. The plan making process will tackle the second area of the study by proposing a suitable method of Grey way Traffic System, Greenway System and Zoning System. This process will lead to develop a development plan for the Nile River Front at Greater Khartoum.

1:10 Stage Four: Evaluation Process

This stage will evaluate the bank stabilization methods from their numerical value arising from the methods or use of construction materials and sustainability. The proposal for the final version development plan for the Sustainable Development of the Nile River Front SDNRF at Greater Khartoum will be evaluated from the summation marks or value of the environmental indicators, economical indicators and social indicators. The evaluation process also will tackle energy use, materials, environmental impact and local impact.

1:11 Stage Five: Implementation Process

This stage develops a set of guidelines for implementing the recommendation. These guidelines will identify the barriers and constraints against implementation and suggestions solutions to overcome them. The implementation process will tackle the requirements for implementing, managing and financing the Sustainable Development elements of the Nile River Front at Greater Khartoum. Finally this stage will identify the limitation of the research and suggest areas for further research.

1:12 Organization of the Thesis

The Thesis will comprise nine chapters as detailed below:

Chapter One: Introduction

The chapter provides an introduction and overview of the research project. It will consider the aims of the study, the research hypothesis, general methodology of the study, types of data to be collected, the thesis organization, the research framework, the expected research outputs and the new contribution to knowledge the research aims to make.

Chapter Two: Historical Context

The chapter provides the historical background of the study area which will include the Nile River, role of the Nile River in ancient civilization, history of Greater Khartoum and planning

policies applied to the study area. These are the Kitchener master plan, Macklin master plan, Doxiadis structural plan and Mafit structural plan for Greater Khartoum.

Chapter Three: Current Context

The chapter provides and presents existing data for the current situation of the study area such as location of the study area, general specifications of the study area, hydrology and morphology of the Nile River, the current situation of the existing land uses and activities along Nile River Shores, the current environmental situations, the existing economic and social activities along Nile River Shores and the main problems restricting the development of the study area. Finally existing data will be gathered on the infrastructure of the region identifying where short falls occur in relation to the proposed development.

Chapter Four: Theory of Sustainability

The chapter examines the theoretical background of sustainable construction and development reviewing the general literature about the role of sustainable development in planning policies, visions for sustainable habitat development, international policies for sustainable urban rivers, engineering visions for the urban rivers and river banks, the Urban River Survey and River Habitat Survey as international methods applied for urban rivers, general theories about sustainable development, general theories about environmental indicators and environmental impact assessment.

Chapter Five: Case Study

This chapter will reveal practical issues related to waterside development and sustainability by examining case study of a similar example, so as to understand how related problems have been tackled elsewhere. For many reasons Cairo, Egypt has been selected to be the case study. This includes similar historical background, current situations, sustainable development schemes, future projects and development plan of the Nile River Front. In this selective case study, the methods used to stabilize the river bank and any issues of sustainability will be identified to inform the sustainable development plan for the study area.

Chapter Six: Guidelines for Methods of Stabilizing Nile River Banks

Based on the theoretical and practical information gained from the previous chapters this chapter will determine a set of guidelines for sustainable stabilization methods for the Nile River Banks. These will be appropriate for the environment and socioeconomic conditions of the region. Each element of this plan will be critically appraised to identify any barriers to its uptake that could occur due to the prevailing regional conditions.

Chapter Seven: Guidelines for Developing Nile River Shores

Based on the information derived from previous chapters this chapter will determine a set of guidelines for developing Nile River Shores and River Fronts adjacent to them. The development plan for the Nile River Front in Greater Khartoum will be invented and developed in comparison to indicators of sustainability revealed earlier in the thesis. The second stage will involve presenting the plan to stakeholders in the area to gain their response and feedback. From this feedback it will be possible to determine any barriers to its uptake that have not been identified and also to provide information to refine the plan.

Chapter Eight: Refinement and Evaluation

The development plan in this chapter will be refined to propose the final version of the development plan for the Nile River Front at Greater Khartoum. The final version of the proposed development plan will tackle the two areas of this study, methods of stabilizing Nile River Banks and development of Nile River Shores. This final version development plan will be evaluated from the summation of the numerical marks or values of the sustainable indicators that measuring the quality of the stabilization methods for each Nile River Banks and urban development elements for Nile River Shores in Greater Khartoum.

Chapter Nine: Conclusions and Recommendations

This chapter will present a final summary and conclude the development plan for the Nile River Front at Greater Khartoum. The chapter will identify the recommendations for implementing those areas in the development plan. Finally the chapter also will identify the limitation of this research and suggest areas for further research. The chapter will address barriers and constraints for the implementation of those identified areas and how to overcome over these barriers as to how the development could be undertaken.

Chapter Ten: Recommendations and Limitation of the research

This chapter will reflect the experience of carrying out the research particularly the study is carried in one of the poor developing countries in the world where it is suffering from civil wars for more than 50 years since its independency on 1956. There is a lack of local data that required for integrated methods that will be used in this research and even accessibility to the few rare data required special relationship and also the chapter will tackle lack of similarities to this unique study area in the world.

1:13 Research Framework

Research framework illustrates the general methodology of the planning process how it works within the different stages of the development process with the main issues of the sustainable development as specified in Fig 1-1.

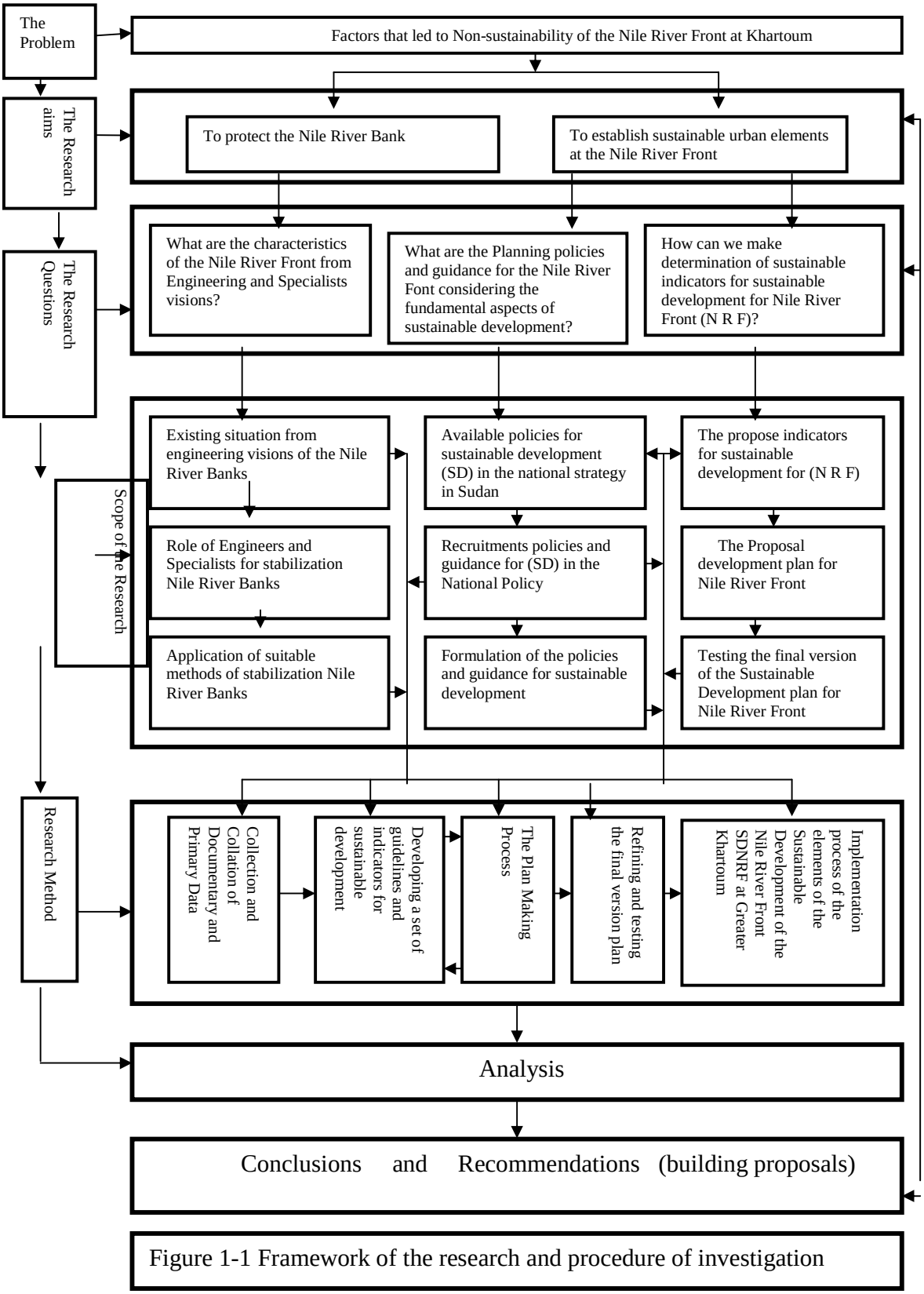


Figure 1-1 Framework of the research and procedure of investigation

1:14 Research Output

It is anticipated that there will be output from this research as follows:

- A comprehensive survey of the Nile River banks as existing to form a baseline against which to measure disturbance or enhancement against. This will form the basis of a set of sustainable indicators against which sustainable degradation or improvement can be measured against in future.

- The establishment of a series of appropriate and sustainable proposals for stabilizing shores of the Nile River Banks. The methods of stabilizing banks vary between the Blue, White and Main Nile River due to the variation of the river pattern system between them. The variation in banks means that no one solution is likely to be suitable. Therefore there will be suggested solutions for the methods of stabilizing each one of the Nile River Banks.

- A set of sustainability guidelines to be used to direct the implementation of the construction and development of the Nile River front in order to minimize its environmental impact.

- The establishment of a set of guidelines and information about sustainable development for the Nile River front at Greater Khartoum which will contribute in rising public awareness about sustainability.

- The establishment of a set of recommendations and guidelines about Sustainable Development of the Nile River Front SDNRF at Greater Khartoum to be considered in National and Local Strategy.

1:15 Intended Contribution to Knowledge

The research aims to provide the following contributions to knowledge:

- Comprehensive survey of the Nile Banks and their adjacent Shores for the six frontages in the study area.

- Establishment of sustainable indicators for developing urban riverfront based on the triangle of sustainability.

- Documentary and Primary Sustainability Data Base that will be useful for sustainable programmes related to Khartoum appropriate to Africa in general.

- Sustainability guidelines for urban areas of rapid economic development that will be useful for those types of development.

- Appropriated Methods of Stabilizing Nile Banks or meandering river in urban areas.

- Sustainability guidelines for river management and protection systems.
- Guidelines for sustainable development plan for waterfront projects and river protection scheme appropriate to the hydrology study area.

- An understanding of the barriers, due to local conditions, that is restricted the development of urban waterfront like Nile Riverfront which may exist to prevent the implementation of the sustainable action plan.

- A set of recommendations to overcome these barriers.

- Sustainability guidelines for rising public awareness about sustainability.

1:16 Conclusion

This chapter set out the context of the research and described the aims of the study. The overall aim is to provide for sustainable protection for Nile River banks to allow sustainable development to take place in Greater Khartoum. The chapter specified the research hypotheses and the methodology that will be used for this research which involves developing proposals from primary and secondary research and then testing the proposals by checking against standards and also by stakeholder survey. The chapter clarifies types of data to be collected whether primary data or secondary data. It went on to specify the organization of the thesis which uses a number of chapters to identify issues of sustainability, river bank protection and sustainable development appropriate to the area and then to develop and refine a set of guidelines

for the application of protection and development schemes in the study area. Finally the chapter presents the expected research outputs and intended contribution to knowledge. The research will provide survey of existing situation of the Nile River shores at Greater Khartoum, a set of sustainability guidelines for study area and a set of recommendations for sustainable action plan.

The next chapter will present the historical background of the study area related to and influencing the research where it will include information on the ancient civilizations in the region along Nile valleys, general historical information about Blue, White and Main Nile River and historical National and Regional planning policies affecting the study area.

CHAPTER TWO: HISTORICAL BACKGROUND

2:0 Introduction:

Chapter Two will consider the historical background and context of the region that is the subject of this research project. Historical information about the study area is essential as it gives us information as to how the region has reached its current status and gives the cultural and geographic information necessary for future developments. Sustainability involves protection and enhancement of the environment, therefore it is essential to have a full understanding of the characteristics and historical development of the region. Historically development was driven by Kitchener Master Plan in 1898, Macklin Plan in 1908 and the Structural Plans of Khartoum in 1958, 1976 and 1992.

This chapter will consider the area by first investigating the Nile River and its surrounding countries known as the Nile Basin Countries and focusing on the specific research area at Greater Khartoum. The chapter will present information about the White Nile, the Blue Nile and the Main River Nile. The chapter will specify the role of the Nile River in ancient civilizations but will focus mainly on the Sudanese civilization following this with the history of Greater Khartoum will be presented. Greater Khartoum is composed of three cities Khartoum, Omdurman and Khartoum North. In additional there is a Small Island at the confluence of the Blue and White Nile called Tuti Island. The chapter will tackle historically the planning policies that applied to the study area within National and local development Strategies.

2:1 Nile River

The Nile River forms the focus for this research project and therefore it is essential that it is understood as well as possible. The Nile River is an alluvial meandering river. Its drainage basin covers about 3112369 km^2 which represents about 10% of the total area of Africa (Nile Basin Initiative (NBI) report, 2003). This area stretches across ten Nile countries namely Rwanda, Burundi, Tanzania, Uganda, Kenya, Democratic Republic of Congo, Ethiopia, Eritrea, Sudan and Egypt. The Nile is connected to an estimated 300 million people that live in these ten countries that share the Nile. The area of these ten countries and the basin as denoted in, the NBI report (2003) is as specified in Table 2-1.

Table 2-1 the Nile Basin Area per Country as specified in NBI report (2003)

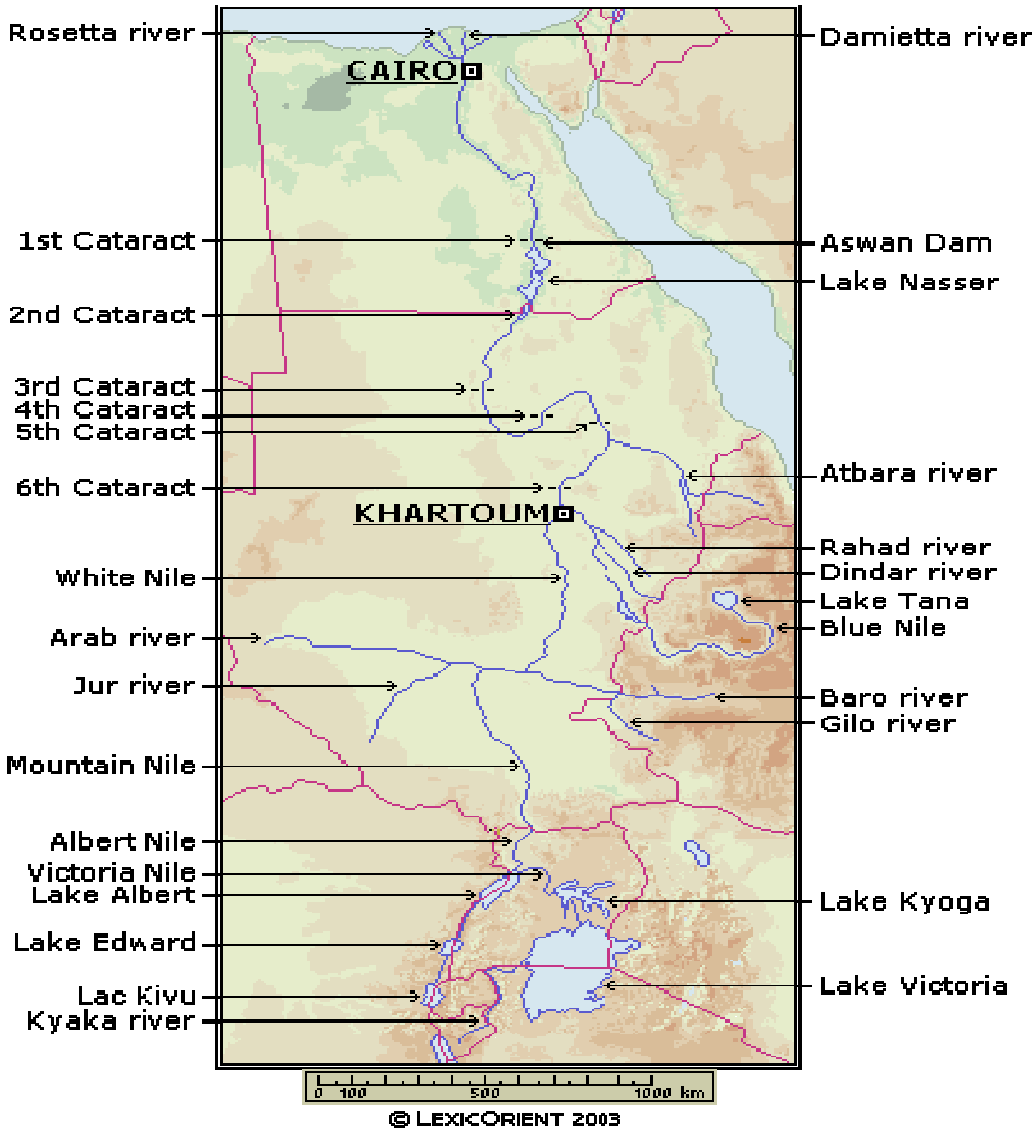
Country	Area of the Country/ km^2	Area of the Country within the Basin/ km^2	As % of total Area Basin	As % of total Area of Country	Average Annual Rainfall in the Basin Area in (mm)		
			%	%	Min.	Max	Mean
Burundi	27,834	13,260	0.4	47.6	895	1570	1110
Rwanda	26,340	19876	0.6	75.5	840	1935	1105
Tanzania	945,090	84,200	2.7	8.9	625	1630	1015
Kenya	580,370	46,229	1.5	8.0	505	1790	1260
Zaire	2,344,860	22,143	0.7	0.9	875	1915	1245
Uganda	235,880	231,366	7.4	98.1	395	2060	1140
Ethiopia	1,100,010	365,117	11.7	33.2	205	2010	1125
Eritrea	121,890	24,921	0.8	20.4	240	665	520
Sudan	2,505,810	1,978,506	63.6	79.0	0	1610	500
Egypt	1,001,450	326,751	10.5	32.6	0	120	15
For Nile Basin		3,112,369	100 %		0	2060	615

It can be seen from this table that Sudan represents the largest contribution to the total Nile basin area, but with the exception of Egypt has the lowest mean annual rainfall. These ten Nile River Basin Countries are shown in Fig 2-1 as illustrates in, Nile Basin Initiative report (2003)

Fig 2-1 The Nile River Basin Countries (source Nile River Basin Initiative)

The Nile River is supplied by many tributaries and lakes as shown in Fig 2-2 as illustrates in, NBI report (2003).

Fig 2-2 Nile River Tributaries and Lakes (source Nile River Basin Initiative)



It can be seen that the Blue and White Nile meet at Khartoum forming the Main Nile River. These rivers will be discussed more fully in the next sections.

2:1:1 Blue Nile

The main source of the Blue Nile, as specified in Nile Basin Initiative report (2003), is Lake Tana in the Ethiopian Highlands, where the river is known to the Ethiopians as The Tigur Abbay. It flows for 850 miles till it meets the White Nile at Khartoum. The river is known in Sudan as the Blue Nile or "Bahr al Azrag". The river represents about 59% of the total annual discharge of the Main Nile River.

The hydrology of the Blue Nile according to the Ministry of Irrigation in Sudan records collected over 50 years from the Blue Nile as specified in (UNESCO Chair in Water Resource Study, 2002), is summarized in Table 2-2.

Table 2-2 Hydrology of the Blue Nile (source UNESCO Chair in Khartoum)

Item	Descriptions	Notes
Maximum Water Level	380.88 m aSL	The average of the Ministry of Irrigation in Sudan records collected over 50 years from the Blue Nile
Minimum Water Level	373.06 m aSL	
Variation Level	7.82 m	
Water slope in flood period	9.7 cm/ km	
Water slope in recession period	7.6 cm/ km	
Maximum Water Level occurred time	Aug- Sept	
Minimum Water Level occurred time	Feb – May	
Width of main stream	420 m	
Width of Blue Nile Left branch at Tuti	246 m	
Width of Blue Nile Right Branch at Tuti	481 m	
Flow in dry period	10 Mm^3/ day	
Flow in flood period	700 Mm^3/ day	
Bank soils	Different types	

From above Table 2-2 it can be seen that there is a high variation in the discharge flow of the Blue Nile between the dry and flood period, the small width of the river in combination with the high discharge flow within the flood period leads to erosion affects and sedimentation. There is also a high slope to the river bank due to the river flow pattern system. Also it can be seen that

banks adjacent to the Blue Nile will experience high water levels between August and September. This means that large flood defences would be needed.

Therefore the Blue Nile is the main concern for any stabilization methods that will be used in the Nile River Banks.

2:1:2 White Nile

The main source of the White Nile, as specified in NBI report (2003), is considered to be Lake Victoria in Tanzania although the lake is fed by many rivers of considerable size. The most distant stream of the White Nile emerges from Nyungwe forest in Rwanda, via Rukarara, Mwago, Nyabarongo and Kagera Rivers. These rivers run through Rwanda and Burundi and finally entering Lake Victoria in Tanzania. The river leaves Lake Victoria at Ripon Falls near to Jinga, Uganda and is known as the Victoria Nile. It flows further for approximately 300 miles through Lake Kyoga into Lake Albert where it known as Albert Nile. Then the river flows into Sudan, where it known as Bahr al Jebel for a length of 445 miles where it meets the Bahr el Ghazal to make one stream called the White Nile or “Bahr al Abyad” which flows to the North till it meets the Blue Nile at Khartoum. The total length from source to Khartoum as denoted by the Ministry of Irrigation in Sudan is 2265 miles.

The hydrology of the White Nile according to the Ministry of Irrigation in Sudan (MIS) records collected over 50 years from the river as denoted in (UNESCO Chair in Water Resource Study, 2002) is summarized in Table 2-3.

Table 2-3 Hydrology of the White Nile

Item	Description	Note
Maximum Water Level	380.66 metre above Sea Level m aSL	The average of the Ministry of Irrigation in Sudan records collected over 50 years from the White Nile
Minimum Water Level	373.21 m aSL	
Variation Level	7.45 m	
Water slope in flood period	5.3 cm/ km	
Water slope in recession period	3.6 cm/ km	
Maximum Water Level occurred time	Aug- Sept	
Minimum Water Level occurred time	Feb – May	
Width of main stream	About 1800 m	
Flow is stable with plus or minus 25 %	73 Million cubic metres per day Mm^3/ day	
Bank soils	Different types	

From Table 2-3 it can be seen that the water flow of the White Nile is stable leading to the formation of a low slope and long shore although there is a high variation in the level between maximum water level during the flood period and minimum water level during the dry period.

2:1:3 Main River Nile

After the Blue and White Nile merge at Khartoum ,the only main tributary is the Atbara River, which originates in Ethiopia and flows for a length of approximately 500 miles until it joins the Main River Nile at Atbara , 200 miles North of Khartoum. This point represents about half of the length of the river until it joins the Mediterranean Sea as the end point of the longest river in the world. The length of the River Nile from Khartoum to its end point at the Mediterranean Sea is 1880 miles. The total length from start to finish is 4145 miles. The Nile River flows from Atbara through the desert till it reaches the man-made Lake Nasser behind The Aswan High Dam in Egypt, 170 miles from the Northern Sudanese border with Egypt. Where another man – made lake from Lake Nasser is made called Toshka. Then the river flows to the North until it reaches the Mediterranean Sea through The Nile Delta.

The hydrology of the Main River Nile according to the Ministry of Irrigation in Sudan records collected over 50 years from the Main River Nile as specified in (UNESCO Chair in Water Resource Study, 2002) is summarized in Table 2-4.

Table 2-4 Hydrology of the Main River Nile

Item	Descriptions	Notes
Maximum Water Level (WL)	376.88 metre (m)	The average of the Ministry of Irrigation in Sudan records collected over 50 years from the Main River Nile
Minimum Water Level	368.82 m	
Variation Level	8.06 m	
Water slope in flood period	8.9 cm/ km	
Water slope in recession period	10.2 cm/ km	
Maximum Water Level occurred time	Aug- Sept	
Minimum Water Level occurred time	Feb – May	
Width of main stream	About 700 m	
Flow due to Blue & White Nile	Above tables	
Bank soils	Different types	

From Table 2-4 it can be seen that the river pattern system is similar to the Blue Nile, the sedimentation and erosion system that occurs due to the small width of the main stream and the high discharge flow of the Blue and White Nile in flood period. Also it can be seen the high variation of water level between flood and dry season and high inclination of the river banks requires special consideration for stabilizing the Main River Nile Banks.

2:2 Role of the River Nile in Ancient Civilization

Most of the ancient civilization in these countries is found along the river basin due to the availability of water. Water is needed for life and the ancient civilizations found in Egypt and Sudan was established here thousands of years ago. These civilizations and other influences on the region are listed in the sections below.

2:2:1 Egyptian Civilizations

From the historical books of Egypt (Abuloughd, 1971 & Abdel Rhman Ali, 2004) the chronological order for Egyptian Civilizations are summarized in Table 2-5

Table 2-5 Summary of chronological period of Egyptian Civilizations

Time Period	Historical Period	Comments
2000000 BC to 3100 BC	Prehistoric Period	1- This period known as Predynastic Period. 2- Start of civilization of the Nile area. Nile used for agriculture, water transport and mud as building material for human settlement. 3- Investigation of the seasons of the year from the flow of the Nile within flood and dry season and hence the observation of the annual cycles which led to an understanding of calendars.
2920 BC to 332 BC	The Dynastic Period from the First Dynasty to the Thirty One Dynasty	1- Construction of human settlements near the Nile River from mud materials due to the behaviour of the short life. 2- Construction of Pyramids, Temples, Parades, Palaces and Sculptures from stones and durable materials because they belief in long life after death.

Time Period	Historical Period	Comments
	Roman and Byzantine Period	1- Construction of churches from masonry materials.
640 AD to 1798 AD	Islamic Period	1- Construction of Islamic Military Towns such as Fustat. 2- Islamic Architecture such as domes and Islamic features. 3- Islamic Town Planning such as Cairo, Damascus and Bagdad.
1798 AD to 1802 AD	French Period	1- Construction of Military Buildings. 2- Town Planning.
1802 AD to 1882 AD	Turkish Period	1- Construction of Industrial Buildings. 2- Construction of new infrastructure such as Dams, Bridges, Canals and Roads. 3- Physical Town Planning.
1882 AD to 1952 AD	British Period	1- Construction of Industrial Buildings. 2- Construction of new infrastructure such as Dams, Bridges, Canals, Railways, Telecommunications and Roads. 3- Physical Town Planning.

From table 2-5 it can be seen that over a long period the organic, unplanned development, using natural local materials was changed for planned development with less dependence on natural products.

2:2:2 Sudanese Civilizations

From the historical books of Sudan (Abusleem, 1970 & Awan Alshreif, 1980)) the chronological orders for Sudanese Civilizations are summarized in Table 2-6.

Table 2-6 Summary of Chronological Period of Sudanese Civilizations

Time Period	Historical Period	Comments
2400 BC to 1500 BC	Karma	1- It was the first Kuchite Kingdom. 2- It was affected by Egyptian Civilizations. 3- They used the Nile water in agriculture and river transport.
1500 BC to 550 BC	Napta	1- It was the second Kuchite Kingdom. 2- The 25th Dynasty of the Egyptian Dynastic Period was ruled both Sudan and Egypt and it belong to this kingdom. 3- The influence of Egyptian civilizations because they ruled by one ruler.
550 BC to 23 AD	Meroe	1- It was the third Kuchite Kingdom. 2- It was characterised by iron and steel industries near the Nile at Meroe royal city. 3- The development of new technical irrigation system from the Nile called Sagia. 4- Construction of Masonry Walls (4m thick) along the Nile Bank to protect the royal city from the Nile Flood. 5- Construction of the Royal City near the Nile River Bank. 6- Construction of pyramids away from the river banks.
23 AD to 1340 AD	Christianity Period	1- It was composed of many kingdoms such as Mugarra or Dongla at the North and Alwa or Soba at the South of it. 2- Construction of churches. 3- The divisions of the Sudan to many kingdoms.

Time Period	Historical Period	Comments
1340 AD to 1820 AD	Islamic Period	1- It was composed of many Islamic Kingdoms at the North of Sudan such as Fungi Kingdom and Darfur Islamic Kingdoms at the West of Sudan. 2- Islamic Architecture. 3- The use of the Nile valley in agriculture and river transport.
1820 AD to 1885 AD	Turkish Egyptian Period	1- The establishment of Sudan today after demolishing Islamic and Christian kingdoms. 2- Division of Sudan to provinces and districts. 3- Construction of new infrastructure such as roads and telecommunications. 4- Planning of Khartoum as new capital for Sudan.
1885 AD to 1898 AD	Mahdiya Period	1- The independency of Sudan. 2- Planning of Omdurman as new capital of Sudan instead of Khartoum. 3- The use of the Nile in agriculture and transport.
1898 AD to 1956 AD	British Egyptian or Condominium Period	1- Division of Sudan to nine Provinces and each Province divided to Municipals. 2- Construction of new infrastructure such as railways, bridges, dams, electricity, roads and telecommunications. 3- The establishment of large development agriculture schemes such as, Gezira Agriculture Scheme and Zidab Agriculture Scheme. 4- Planning of Khartoum as capital of Sudan.

Table 2-6 shows there has been an historic requirement for water management and river stabilization bank to permit safely development along river front.

2:3 History of Greater Khartoum

Greater Khartoum is composed of three cities Khartoum, Omdurman and Khartoum North and also a small island called Tuti. The following sections describe the history of these.

Khartoum

Khartoum was established as the capital of Sudan within the Turkish Empire in 1821 AD after the Turkish had overthrown the Funj Kingdom and moved the capital from Sennar to Medani then to Khartoum. Before the influence of the Turkish, Khartoum was composed of small scattered settlements or villages such as the village of Sheikh Arbab al Agaid which was established in 1620 AD. Sheikh Arbab al Agaid was well known within Funj Period and established his famous Massid for Quraan in Tuti Island and later moved it to Khartoum in 1691 AD which became very famous in Sudan, where his student numbers reached more than a thousand at that time. Sheikh Alameen Eldreer also came from Tuti establishing the famous Islamic Centre in Sudan during this period in Khartoum. Soba which is now part of Greater Khartoum was the capital of the Christian kingdom called Alwa which was established in the fifth century and demolished by Funj in 1504 AD.

The Turkish further established the town in 1821 AD by constructing government buildings along the Blue Nile as the first zone. Two other zones were created one as governmental housing and another zone as a market area. This area was well planned and had good connections to Egypt by telegraph and the other communications and services methods invented at that time. Other zones for the general population were unplanned called local native settlement.

When Mahdiya captured Khartoum in 1885 AD they moved the capital from Khartoum to Omdurman.

When Kitchener overthrew Mahdiya by his Anglo-Egyptian Nile Expeditionary Force at Karri battle in 1898 AD, he returned the capital to Khartoum again. Kitchener made a master plan for

Khartoum in1899 AD based on the Washington master plan. The railway reached Khartoum after constructing the Blue Nile Bridge from steel. This period show the establishment of good infrastructure, radial roads, recreational areas and most of the urban facilities required at that time.

Omdurman

Omdurman became capital of Sudan within the Mahdiya period 1885-1898 AD when Anssar captured Khartoum they moved the capital to Omdurman and called it Bugat Elmhadi. Khalifa Abd Allahi was planning the town according to the Islamic Pattern, as some planners in Sudan like Salah Mazari said so. The town is divided to different sectors or zones in a way that each sector or zone had a specific function or purpose. For example Bait- Al-Khalifa was established as high political quarter situated in the middle so as to be equally accessible for the whole public. The Soque sector was established as a commercial zone situated near the political zone. An import and export zone was situated near the river for loading and unloading of ships and boats called El-Morda, other residential zones are situated such as Bait- Elmal as financing zone, Wad- Nobawi, Elmlazmine, Aboroof, Wad- Doro, El-Abbasia, Elmasalma, Hai-Elarab etc.

Omdurman before Mahadiya was composed of small settlements or villages, most of them built by the Gamoia tribe, but a famous Sheikh from Tuti called Hammed Wad- Ummarume established his popular Massid for Koran at Omdurman within Funj Period (sixteenth century).

Old –Omdurman required re-planning, but most of the land owners required high compensation due the high value of the land here. This resulted in a great delay in executing the re-planning development plan, although the new extensions of Omdurman were well planned and supplied with most of the required services.

Khartoum North

Khartoum North was mainly established as a modern town by Kitchener, as a result of his using the river port for his ships and boats in 1898 AD. He constructed big workshops and warehouses as headquarters for river and sea transport which was named the River Transport Corporation.

This corporation required a lot of employees and local workers, therefore most of the population of Khartoum North were workers at that time.

Khartoum North gradually expanded by the creation of a large industrial area containing different types of industries like food processing industries, oil industries, soaps industries, chemical and related industries. In addition different types of commercial and residential areas also grew up to support the industrial activities.

Tuti Island

Tuti is a crescent-shaped island built up as a result of mud sedimentation on the sedimentary rocks, which are noticeable in the middle of the island. The total area of the island is about one thousand and two hundred acres. The population of Tuti is mainly composed from Mihas tribe whom emigrated from Northern Sudan within the Funj Period during the sixteenth century.

Tuti has a unique location for we find the Blue Nile flows from the East, the White Nile from South and West and the River Nile from North. The total length of the shores of the three rivers is 10.375 Km. Unfortunately all these shores are not protected against flood, which presents a great risks to the people and their property on the island during the flood season.

Summary

From this brief of historical background of Greater Khartoum we can identify the following:

- The development was largely agriculture based related to the need to feed population for many years.

- Presence of the British led to an upsurge in development, but this was based on trade and military necessities.

- Khartoum is now poised for new phases of development, but two essential issues are required the Nile River Banks needs to be stabilized and also there is a need to construct in a sustainable manner.

2:4 Planning Policies Applied to the Study Area in National and Local Strategy

There are few places in the world where development can take place without restrictions. This section aims to summarize the planning laws that govern development in the region. The main policies applicable to and affected developments in Greater Khartoum include both historical plans and current legislations are summarized below:

2:4:1 Kitchener Master Plan 1898

The Kitchener master plan was the first managed plan of development applied to Khartoum. It used similar assumptions as that applied to the Washington master plan. The governmental buildings were located along the shore of the Blue Nile, then the residential housing for English and Egyptian high ranking officers and the native stretched in scatters settlements at the South of the railway station not constituting in the structural plan. The location of the railway now becomes one of the most obstacles of the natural development.

2:4:2 Macklin Master Plan 1908

The Macklin master plan was a modification of the Kitchener master plan, which was influenced mainly by the idea of garden city model. Large parks were located near the Nile like Khartoum International Zoo, nice parks along the Blue Nile like those within the ministry of finance, ministry of irrigations and all parks within those traditional buildings.
Then the general commissioner of Khartoum called Sarsfield Hall applied another modifications and amendments for Kitchener and Macklin master plans.

2:4:3 The Structural Plan of Khartoum 1958

The structural plan for Khartoum in 1958 was designed by Doxiadis Associational Consulting Engineers within the first elected democratic government period (1956-1958) after the independence of Sudan in January 1956. The structural plan was depending on the dynamic development of the city based on the natural characteristics of the Nile River and the three cities located on it; Khartoum, Khartoum North and Omdurman that formed Greater Khartoum. The structural plan specified the direction of the development in Greater Khartoum and for our study area as the most dynamic and valuable area in Khartoum, the plan was tackled the following issues:-

- To develop the function of the Nile River to be as a source of beauty and communication for Greater Khartoum and not as obstacles between the three cities. This obtained by using the Nile River as main blue way for urban activities such as; recreational, leisure's, water based sports, tourists, landscape and fisheries.

- Protection of Nile River Banks by suitable stabilization methods.

- To develop the Nile River Shores for mix used urban elements.

- To protect the agricultural and green areas on both sides of the Nile Riverfront.

- To eliminate pollution to the water of the Nile River by establishing suitable legislations that required for this purpose.

The structural plan for Khartoum in 1958 as illustrated in Fig 2-3 was tackled the main problems that restricted the development in our study area and suggested suitable solutions for them, but nothing was implemented from them for the following reasons:-

- When the plan was designed and ready for implementation the elected democratic government was changed by military troops and new military government was take place in November 1958. The military government altered and cancelled all the previous

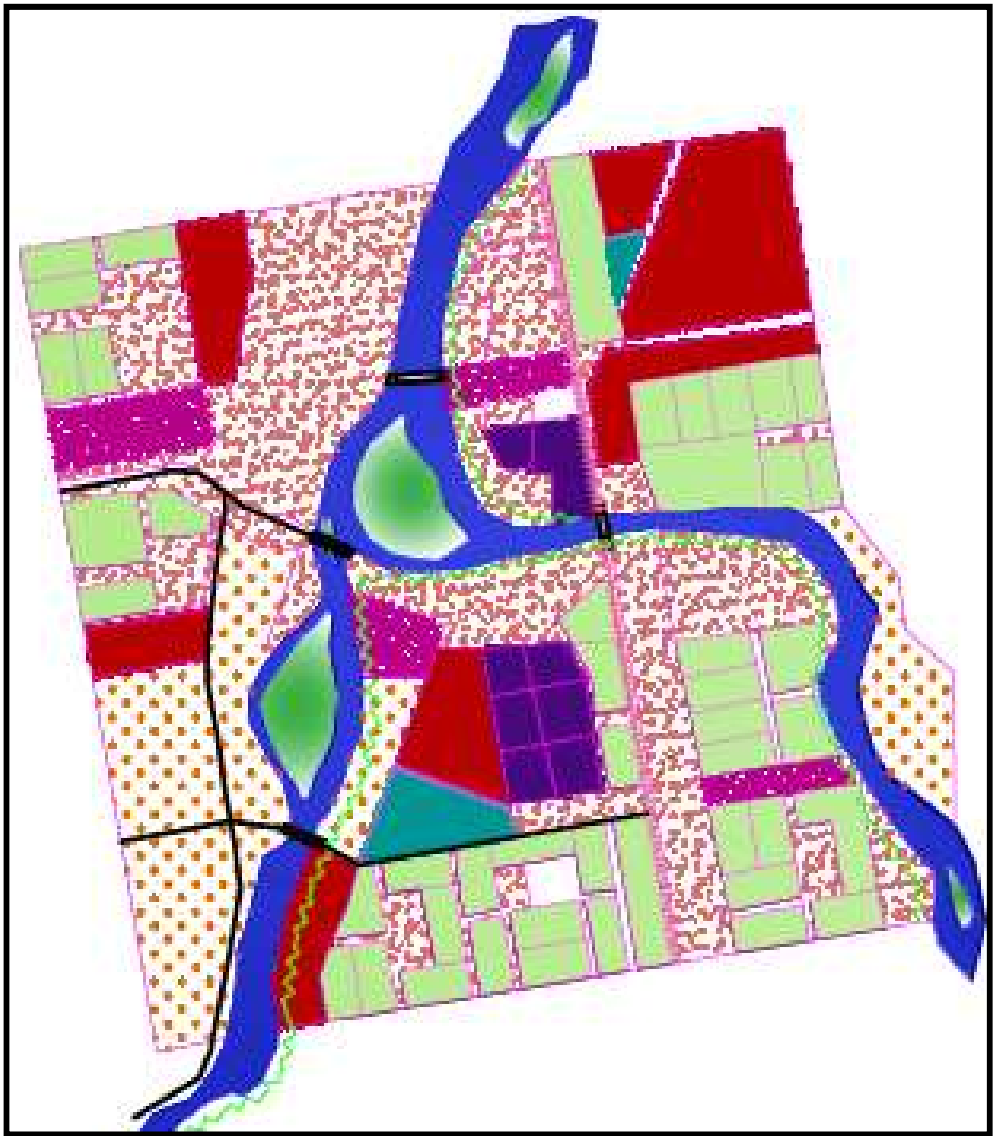
programmes that issued within the first democratic period and created new agendas due to the new military government programmes.

- Starting of civil wars in South of Sudan due to the military agendas. Therefore the military council changed their priorities for different development programmes due to these visions.

- The bad economic situation of Sudan which is considered as one of the poorest countries in the world due to regional and international indicators. This situation led to restrict implementation for most of important programmes.

- The military period (1958- 1964) was changed by public revolution in October 1964 and new elected democratic government was appointed that known with the second democratic period (1964-1969). Then the military changed the second elected democratic government and a second military period started in June 1969 till April 1985. This insatiability of politics led to non sustainability of development.

Fig 2-3 The Structural Plan of Khartoum (1958) source Doxiadis Plan No 23



KHARTOUM STRUCTURAL PLAN 1958			
	RESIDANTIAL EXISTING AREA		Proposal Cornice
	INDUSTRIAL AREA		REGIONAL ROAD
	AGRICULTURAL AREA		Existing Bridge
	NATIONAL RAILWAY		Proposal Bridge

2:4:4 The Structural Plan of Khartoum -1976

The structural plan of Khartoum in 1976 was designed by Mafit Consulting Planning Groups within the second military period (1969-1985). The plan was considered the previous structural plan in 1958 and tackled the following issues in our study area:-

- The structural plan concentrated on developing the city centre and establishing recreational and landscape urban elements on the Nile Riverfront in Khartoum.
- The structural plan restricted the development along Nile Riverfront and any development should be according to specific; classifications, specifications, building types, building height, building regulations and distance from Nile Banks.
- The structural plan directed that all shores should be accessible to public.
- The structural plan was directed for protecting Nile Banks with suitable stabilization methods and establishes cornice along Nile Riverfront.

The structural plan of Khartoum in 1976 as illustrated in Fig 2-4, as the previous one in 1958, nothing of the development elements in our study area were implemented for the following reasons:-

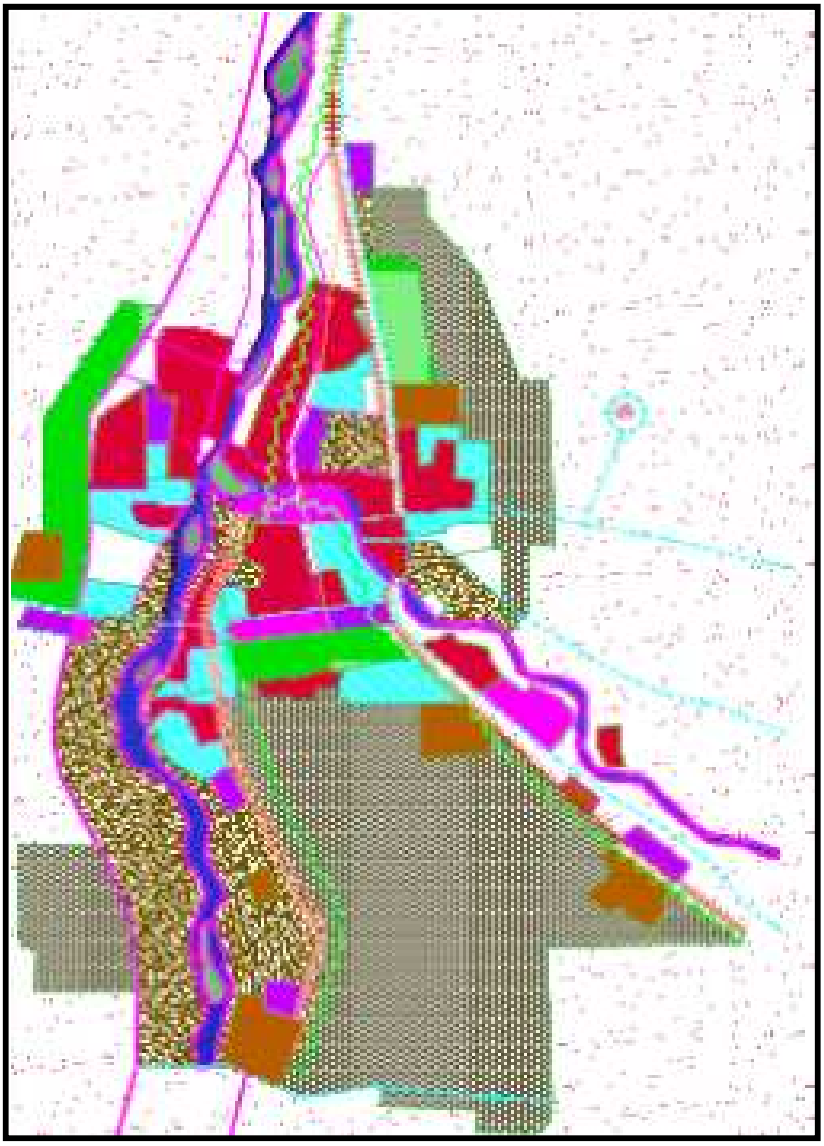
- The Sudan economic situation was still considered one of the poorest countries in the world according to regional and international economic indicators that caused the implementation of this plan impossible.
- The absence of democracy and representation of public in the Parliament where all its members were appointed by military ruler.
- The absence of transparency and democracy led the; planning, plan making and planning control to be according to the military ruler wishes and not to the concept and planning

system. Therefore implementations for development elements take place according to the ruler desire and not to scientific planning programmes.

- The continuous changes of governments particularly the democratic periods were very short related to military ones that led the planning concept to be of continuous changes and not sustainable due to the rapid political changes. This situation led to most of development programmes not to be implemented.

- The starting of civil wars in South of Sudan from time to time particularly in 1983 led the military ruler to change his agendas and let the Sudan to be suffering from these wars and military rulers.

Fig 2-4 the Structural Plan of Khartoum (1976) source Mafit Plan No 25



KHARTOUM STRUCTURAL PLAN 1976			
	RESIDANTIAL EXISTING AREA		NATIONAL RAILWAY
	RESIDENTIAL DEVELOPMENT		NEW AIRPORT AREA
	NEW URBAN ENTITY		Proposal Corridor
	LARGE SERVICES		REGIONAL ROAD
	INDUSTRIAL AREA		METROPOLITAN RAILWAY
	AGRICULTURAL AREA		URBAN ROAD
	SEWAGE AREA		

2:4:5 The Structural Plan of Khartoum 1992

The structural plan for Greater Khartoum in 1992 was designed by Doxiadis Associational Consulting Engineers. The plan was designed within the third military period that changed the third elected democratic government that started after the second public revolution in April 1985. This period called the third democracy period and extended from April 1985 till June 1989 where military troops changed the elected government and the military ruler appointed military government in June 1989 and this period extended till now.

The structural plan of Khartoum proposed in 1992 was devised to tackle the main problems perceived in previous Greater Khartoum development referring to the partial and ad-hoc solutions arising from the last structural plans. The structural plan in 1992 focussed on the homogeneity, continuity and functionality of the different urban elements in sustainable way without concentration only on the centre. This issue could be achieved by creating sub-centres. The structural plan for Grater Khartoum in 1992 as illustrated in Fig 2-5 was tackled the following development issues in our study area:-

- The structural plan focused on the homogeneity, continuity and functionality of the development elements along Nile Riverfront in Greater Khartoum.

- The structural plan directed for further scientific studies to the hydrology, morphology and geotechnical for the Nile River pattern system in Greater Khartoum. This studies such as the study of the centre of Khartoum that carried by Khartoum CBD Study Team in 1999 and the study carried by UNESCO Chair in Water Resources in 2002.

- The important of the waterfront development as homogenous area that should be developed to improve the general environment in Greater Khartoum.

- To create urban elements along riverfront after stabilizing the Nile Banks and to make Nile Riverfront accessible to public.

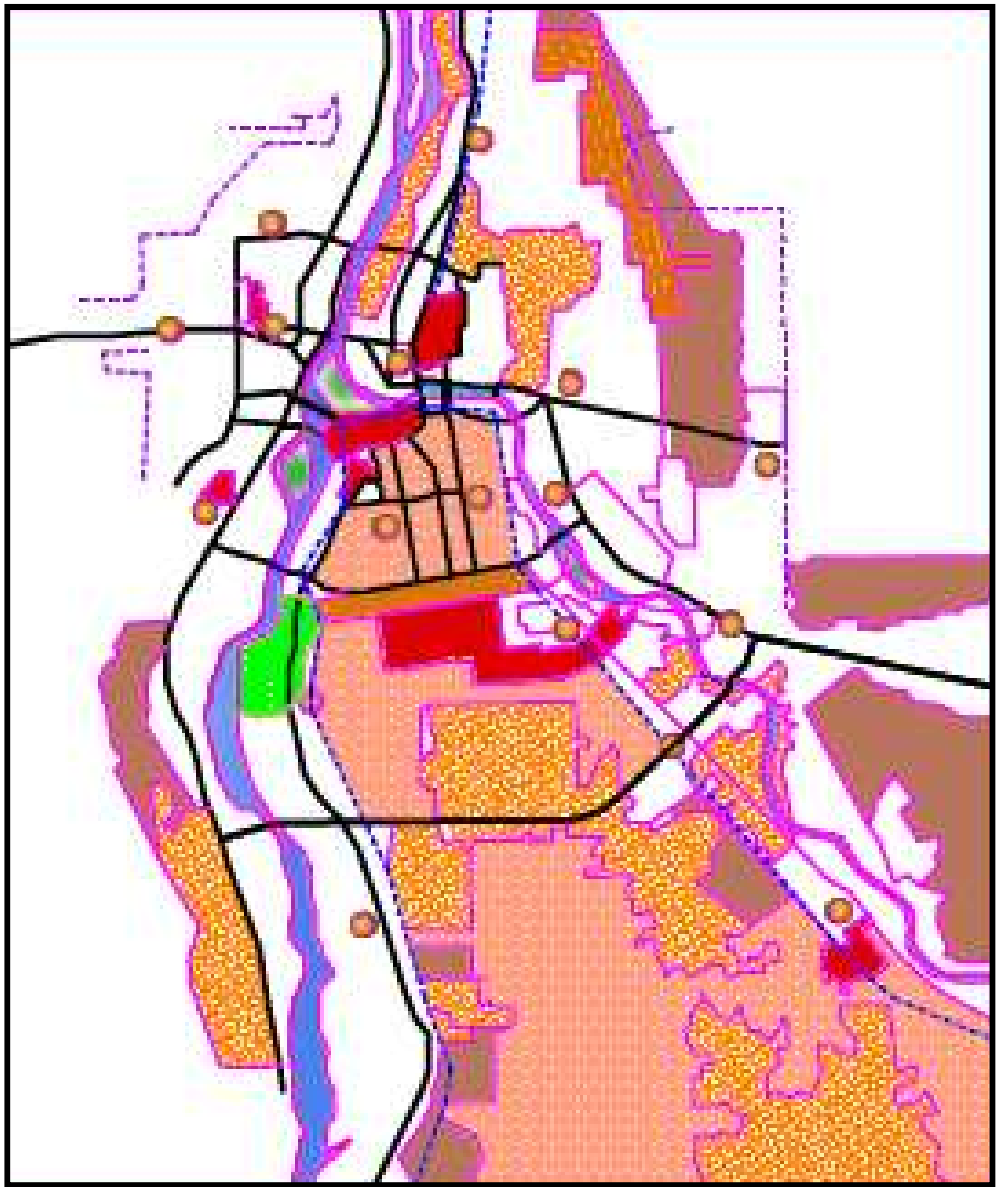
- The structural plan divided the riverfront to zones extended along the six frontages shores.
- The structural plan directed to establish the required legislations and regulations that required for controlling and directing the development of the Nile Riverfront.

The structural plan for Greater Khartoum in 1992 was not implemented particularly those related to our study area and this is related to the following reasons:-

- Lack of military ruler visions due the absence of transparency and democratic institutions.

- The bad economic situations of Sudan in spite of its potential natural resources where more than 75% of the national income expended for security.

Fig 2-5 the Structural Plan of Khartoum (1992) source Doxiadis Plan No 26



2:5 Summary of Chapter Two

This chapter presented the historical and contemporary background of the study area especially the contribution and role of the Nile River in ancient civilizations particularly the Egyptian and Sudanese civilizations. The chapter gave short information about the ten Nile Countries, known as Nile Basin Countries and the Nile Basin Initiative NBI which is the official coordinator body responsible from the development of the Nile River Basin within these ten Nile Countries. The chapter presented the hydrology of the Blue, White and Main Nile River from the recorded data collected for 50 years by the Ministry of Irrigation in Sudan. The chapter summarized the chronological order of Egyptian and Sudanese civilizations and the role of the Nile River in those civilizations. The chapter gave short brief about historical background of Greater Khartoum which composed of three cities Khartoum, Omdurman and Khartoum North followed by the small island at the confluence of the Blue and White Nile forming the Main Nile and it is called Tuti Island. The chapter finally summarized the historical planning policies applied to the study area in national and local strategy from the first master plan by Kitchener in 1898 AD until the structural plan in 1992 AD.

The information presented in this chapter shows that the region has a rich and historical background. Moving on form a large agricultural society various powers have attempted planning for a more development society utilizing educational, commercial and residential areas served by modern communication systems. Further development is likely and will be influenced by these past plans.

The next chapter will concentrate on data gathering and research and the chapter will expand information about the current state of the study area given in this chapter.

CHAPTER THREE: - CURRENT SITUATIONS

3:0 Introduction:

The aim of this chapter is to present the results of a survey into the current state of the Nile River Shores and the Riverfronts or the adjacent land to these Shores. The chapter will do this by dividing the large River Shores length into 16 manageable zones or Shores and Riverfronts. The issues that will be surveyed will indicate and tackle:

- Drives of development in the study area.
- Sudan general economy which will indicate, it can support such kinds of riverfront development.
- Current environmental and social situations of the study area, which reflect a lacks of existing infrastructures and needs of riverfront development programme.
- Reasons of dividing the study area into 16 Nile Shores and location of them on the Blue Nile, the White Nile, the Main Nile and the Confluences of the Blue and White Nile at Tuti Island.
- The general characteristics and specifications of each Nile River Shore and the Riverfront adjacent to it.
- Photographic record for each Nile River Shore and its Riverfront.

The reason for carrying out this survey is to provide base- line information about the study area with those collected in previous chapters. In particular information is required about the need and options for riverbanks stabilization methods and development of Nile Riverfront in Greater Khartoum.

3:1 Overall Drivers of Development in the Study Area

This section will explain why this region has been identified as a location which is likely to be developed. The region identified in the previous chapter has been recognized as an area where it is anticipated that rapid development is going to take place. This has been suggested for a number of reasons. The following section highlights the main driving factors:

3:1:1 World Famous

(i) The Nile is a river known throughout the world.

(ii) The location of the development area adjacent to the Nile will make marketing publicity much easier and increase the land value.

3:1:2 Prime Location

(i) Sudan is the largest country in Africa where it is known as “the heart of Africa” and Khartoum as the capital of Sudan is well placed to be a central business hub for the continent.

(ii) Evaporative cooling from the River Nile helps the microclimate. Generally cooler and a more comfortable humidity than the region away from the river.

(iii) Khartoum has a strong historical background demonstrated by the buildings left behind for example in Turkish and British- Egyptian Period.

(iv) River fronts are well known as desirable locations for living and working. The Nile River benefits from appearance of the continuous flow and natural visions of flora and fauna.

3:1:3 Facilities

(i) Concentration of the most governmental and public buildings along the Nile Shores. This means that there is already a precedent for development and an infrastructure in place to help it proceed.

(ii) Most of existing recreational facilities are located along the Nile Shores. This will lead to develop these facilities and to create new ones.

(iii) The existing infrastructure along the Nile Shore that can be enhanced to improve the public services in the area.

(iv) River resource for water transport.

(v) Local food supply from agriculture.

(vi) Local population for skills.

In recent years the Sudan has seen much investment from outside countries that hope to share in the regions wealth of natural resource. The exploitation of those resources will require a modern city infrastructure in which to accommodate stakeholders in this development. The drives described above in addition to this highlight Khartoum as a region where rapid urbanization is poised to take place.

3:2 Sudan General Economy

The Sudan General Economy will tackle economic overview, economic structure and Gross Domestic Product GDP for Sudan as specified below:

3:2:1 Economic Overview

Sudan is a rich country in terms of natural and human resources, but the economic and social development have been below expectation. Sudan is considered one of the poorest countries in the world by both regional and international standards due to the civil wars in South and Darfur region, the poor economic management, coupled with the severe economic disruption and imbalances caused by the civil war have blocked successful development in Sudan. But this situation will be altered if the Comprehensive Peace Agreement CPA between the Government or National Congress Party NCP and Sudan People's Liberation Movement SPLM in (May, 2005) and Darfur Peace Agreement in Abuja in (2006) are brought into effect, but it will take many years to overcome on the effect and impact of these civil wars in Sudan.

In terms of both employment and contribution to GDP, agriculture is the most important sector where it employs 80% of the total workforce in Sudan and considered a third sector that contributes in the GDP. The agriculture sector is dominated by several key crops produced by a combination of rain-fed and irrigated agriculture, including the vast al-Gezira irrigation scheme.

Sudan economic structure was changed and altered after the petroleum invention and production in (1999), which lead to large inflows of foreign direct investments.

Lake of basic infrastructure in large areas, and reliance by much of the population on subsistence agriculture ensure much of the population to remain at or below poverty line despite rapid rises in average per capita income. Generally Table 3-1 and 3-2 illustrates the macroeconomic framework in (2008) and trade balance from (2000 to 2006) by the Ministry of Finance and National Economy MFNE in Sudan report as specified below:

Table 3-1 Macroeconomic Framework for Sudan source MFNE report Sudan (2008)

Item/ year	1999	2005		2006		2007		2008	
		Budget	Revised	Budget	Est.	Budget	Est.	Budget	Est.
Total population in Million	30.0	35.3	35.3	36.2	36.2	37.1	37.1	38.0	38.0
Real GDP Growth Rate	6.7%	8.0%	8.0%	10%	10%	10.5%	10.5%	7.6%	7.6%
Real GDP Bill SD 81/82 prices	1354	2040	2040	2244	2244	2469	2480	2657	2679
General Price inflation*	16.0%	7.5%	8.5%	8.0%	7.2%	8.0%	8.3%	6.7%	8.0%
GDP Deflator (General Price)	199.9	326	329	352	352	377	378	402	404.6
Exchange Rate	252.1	250	243.6	225	217.1	200	200	200	2.00
GDP Current prices BSD	2706	6646	6708	7896	7910	9310	9379	10667	108,381
GDP current prices in US $Billion	10.7	26.6	27.5	35.1	36.43	46.6	46.9	53.3	54.2
Per capita in US $	358	753	780	970	1007	1255	1264	1402	1425
Total Consumption	2273	5300	6108	6058	3090	1035	2385	1987	89622
Government Consumption	197	1059	1385	1591	12449	14868	13678	13377	11952
Private Consumption	2076	4241	4723	4467	9358	13834	11293	11390	77670
Gross Domestic Saving	433	1347	600	1838	4820	8276	6994	8679	18759
National Saving	433	1039	74	1681	3794	7621	6339	7677	8730
Total Investment	433	1655	1275	1994	5845	8931	7649	9682	28787
Government Investment	33.4	392	0	494	4421	7069	5773	7442	6027
Private Investment	400	1263	1275	1500	1424	1862	1876	2240	22760
Current Account Billion SD	0	308	674	156	1025	655	655	1003	10029
ICOR	2.4	3.1	2.4	3.0	7.4	9.6	7.8	11.9	3..3

Table 3-1 illustrates that the GDP of Sudan is of significant increase due to the increase in petroleum products and rates, the total private and governmental consumption is increased from 1999 to 2008 to 37 and 60 times respectively that reflect the Sudan economic problems related to the high consumption of government compare to the less amount for the development and the noticeable increased in the total investment in Sudan from 1999 to 2008 to 66 times.

Table 3-2 Trade Balance in US $ Millions (2000-2006) source Central Bank of Sudan

year	2000	2001	2002	2003	2004	2005	2006
Exports (FOB)	1,806.70	1,698.70	1,949.11	2,542.17	3,777.75	4,824.28	5,656.56
Imports (FOB)	1,366.4	2,024.8	2,152.8	2,536.1	3,586.2	5,946.0	7,104.7
Trade Balance	440.3	326.1	203.7	6.1	191.6	1,121.7	1,448.1

Table 3-2 illustrates that the Sudan exports trade is increased from 2000 to 2006 to 3.13 times and the imports to 5.2 times.

3:2:2 Economic Structures

Economic structures generally in Sudan and study area are agriculture base. The below section specified the most important economic sectors as summarized below:

3:2:2:1 Agriculture

Most of the lands in Sudan are flat because 67% of the Nile Basin flat area lies in Sudan where more than 200 million hectare suitable for agriculture, fortunately the cultivation area represent only 10% from the total suitable agricultural area. Agriculture production as specified in the world fact book for Sudan (2008, p.7) is the most important sector in Sudan which employing 80% of the workforce and contributing to the GDP 38.7% in the year (2003) and 31.5% in the

year (2007). The main agricultural products are cotton, groundnuts (peanuts), millet, sorghum, wheat, gum Arabic, sugarcane, cassava (tapioca), mangos, papaya, bananas, sweet potatoes, sesame, vegetables, fruits, orange, livestock.

3:2:2:2 Industries

Industry sector, as specified in above source, is occupying 7% of the total labour force in Sudan and contributing to the GDP 20.3% in the year (2003) and 35.7% in the year (2007). This significant increase in industrial sector is resultant from petroleum production and most of the important other industries are cotton ginning, textiles, cement, sugar, soap, distilling, shoes, pharmaceuticals, armaments, automobile/ light truck assembly and oil industries. The petroleum exportation products started as specified in the world fact book for Sudan (2009, p. 8) is in (August, 1999) following the opening of 16oo km oil export pipeline and production of crude oil is of continuous increase from 209,100 barrels/ day in the year (2001) to 750,000 barrels/ day in the year (2008) while local consumption is 79,760 barrels per day.

3:2:2:3 Services

Services sector occupying 13% of the total labour forces in Sudan and contributing to the GDP 41% in the year (2003) and decreasing to 32.8% in the year (2007). This significant decrease in services sector is due to the lack of proper planning by the government and deterioration of agriculture sector which has negative impact to service sector.

3:2:3 Gross Domestic Products GDP

Gross Domestic Products GDP in Sudan is of significant grow since petroleum production in (1997) that led to increase exportation volumes combine with rapidly growing in foreign investment flows into large capital projects and buoyant domestic demand. The GDP real growth rate as specified in MFNE report (2008) increase from 5.9% in the year (2003) to 11% in the year (2007). The purchasing power parity is $70.95 Billion in the year (2003) that increased to 107.8 Billion in the year (2007). Contribution of different economic sectors to the GDP as specified in MFNE report is summarized in Table 3-3.

Table 3-3 GDP in Local Current Sudanese Dinnars SDD Millions (source report of MFNE-Central Bank of Sudan, 2008).

Specifications	2005	2006	2007
Agriculture	754.2	785.6	810.3
Irrigated Crops	206.7	230.7	238.9
Rain fed mechanised crops	27.1	27.1	20.6
Rain traditional crops	103.4	107.4	114.1
Livestock	368.7	370.1	384.9
Forest and others	48.3	50.2	51.7
Industry	534.7	603	742.9
Mining and quarrying	301	350	461
Petroleum	288	336	447
Others	13	14	14
Manufacturing	130	140	160
Electricity and water	26	28	30
Construction	77	85	92
Services	608.5	663.2	723.3
Government Services	200.8	222.8	245.5
Other Services	407.8	440.4	477.8
GDP, Fact. Cost, Conc. P.	1,897.4	2,052	2,276
Annual Change %	9%	8%	11.0%
GDP Deflation	344995.1	373975	403892.7
GDP, Fact. Cost, Current Prices	6,546,013	7,672,852	9,194,565

Table 3-3 illustrates that the agriculture sector is not increased in spite of the increased in the petroleum production that mean the government is depend on the petroleum product although Sudan is agriculture country and the increased in the GDP that can support more development projects.

3:3 Current Social Situations

The current social situations will tackle demographic characteristics, age structures of demographics characteristics, public services as specified below:

3:3:1 Demographic Characteristics

There were five national censuses taken in Sudan in the years 1953, 1973, 1983, 1993 and 2008. From these censuses the population of Sudan is of recognizable increase due to the high fertility rate which is 2.8 in urban areas and 3.5 in rural areas. The total population of Sudan in (1973, 1983 and 2008) were 14113590, 20594197 and 39451212 respectively.

Also there is a significance increase in the population of Greater Khartoum occurred due to local civil wars in South, West and East of Sudan that leads high migration from these regions to Greater Khartoum. The population of Greater Khartoum were 1.2 million in (1953) and in (2008) were 5,274,321 as specified below:

(i) Khartoum = 1,582,027 where 806,834 males and 775,193 females
(ii) Khartoum North = 1,476,964 where 753,252 males and 723,712 females
(iii)Omdurman = 2,215,330 where 1,129,818 males and 1,085,512 females

3:3:2 Age Structure

The age groups are divided for each five years or can be divided due to school age groups such as kindergartens (4 years), primary or elementary schools (5-14 years), secondary and high education schools (15-29 years), after graduation years (30-64) and old people above 64 years and the percentages of these categories are as specified below:

0-4 = 15%

5-14 = 28.7%
15- 29 = 27.5 %
30 – 64 = 26.5 %
> 64 = 2.3 %

3:3:3 Public Services

The current public services tackled telecommunications systems, electricity, methods of transportation, human health and educations in Sudan and the study area as specified in the below sections:

3:3:3:1 Telic-Communication Systems

Communication system in Sudan is considered one of the modern large, well-equipped systems by the regional standards and upgraded, cellular communications started in (1996) and have expanded substantially. The system consists of microwave radio relay, cable, radiotelephone communications, troposphere scatter, and domestic satellite system with earth stations. The telephones mainlines in use as specified in the world fact book (2006 p.9) is decreasing from 900,000 in (2003) to 636,900 in (2006), while telephones mobile cellular is increasing from 650,000 in (2003) to 4.683 million in (2006). The radio broadcast stations are AM (12), FM(1), shortwave (1) where the radios are estimated at 7.55 million in 1997. The internet service providers (ISPs) as specified in the Ministry of Communication in Sudan report (2006) are 5 where the users are estimated at 3.5 million.

3:3:3:2 Electricity

Production of electricity in Sudan as specified in the Ministry of Finance report in (December, 2007, p. 8) is either by fossil fuel or by hydro turbines. The production of electricity is of significant increase where we find it 515 MW in (1990) and 1139 Mw in (2006). But the significant increase in electricity production will be from Merowi High Dam North Khartoum in the year (2009), where the annual production from the dam is 1250 MW.

3:3:3:3 Transportations

Sudan is the largest country in Africa. There are different methods of transportation as specified below:

(i) Roadways

The total length of roadway, as estimated in the world fact book for Sudan (2006, p.10) is 11,900 km where 4320 km paved and 7580 km unpaved.

(ii) Railways

Sudan is the largest country in Africa with total area of 2,505,810 sq km where 2.376 million sq km is flat land with small hills and 129,810 sq km is water area. This large area the suitable and economical transportation method is the railway system, but fortunately there is no proper planning and future vision for developing this suitable type of transportation method in Sudan, therefore it is deteriorated and about to collapse. The railways lines in Sudan as specified in the word fact book for Sudan (2006,p.10) are narrow gauge of total length 5978 km where 4578 km is 1.067 m gauge and 1400 km is 0.600 m gauge used for cotton transportation in Gezira Scheme.

(iii) Airports

The total airports in Sudan are increased from 63 airports in (2003) where only 12 airports are paved and the remaining airports are unpaved to 101 airports in (2007) where 16 airports are paved and 85 airports are unpaved. The runway in paved airports is varies where 2 runway over 3047m, 9 runway between 2438m to 3047m, 4 runway between 1524m to2437m and one runway under 914m (source the world fact book for Sudan, 2007, p.11).

(iv) Waterways Transportation

The total length of the Red Sea coastline in Sudan is 853 km where there are three sea ports namely Port- Sudan (main Sudan port), Suakin and Bashair which specialized in Petroleum export. Blue waterways of Blue, White and Main Nile River are used in local transportation methods between various Sudanese cities and villages for population and their goods and animals. These waterways transportation methods can be developed by establishing and constructing suitable sustainable harbours and modern river cruises or navigation vessels. The total length of waterways in Sudan that used permanently in the Nile River is 4068 km (source the World fact book for Sudan, 2006, p.12).

3:3:3:4 Human Health

Human health service in Sudan is ranging and in hierarchical way that starting from dressing station and dispensary in rural areas to clinic, health centre, hospital and specialized hospital in urban areas. Health situation is deteriorated in governmental units in Sudan due to civil wars in Darfur and South Sudan, therefore most of the population used private hospitals and private health centres. The number of hospitals increased in Sudan from 205 in (1989) to 375 in (2006) and the number of beds increased from 19,200 in (1989) to 30,000 in (2006). But in spite of this significant quantitative increase there is qualitative decrease. Also the number of doctors increased in Sudan from 9.4 doctors for each 100,000 persons in (1989) to 19 doctors for each 100,000 persons in (2006) and child death rate for those below five years old decreased from 124/ 1000 in (1989) to 102/1000 in (2006), (source Ministry of Health report in Sudan, December, 2007, p.8-9).

3:3:3:5 Education

Education system in Sudan either governmental type or private type for the various educational levels which namely kindergartens of 3 years duration, elementary school of 8 years duration, secondary school of 3 years duration and high education in university or polytechnic which ranging between 3 to 6 years. Fortunately, educational system in Sudan is deteriorated in governmental school that leads to significant increases in private a school as seen from the stretches and expansions of private schools and universities in Sudanese cities without proper clear planning policies or educational measurements. This private education system becomes a source of profit for unauthorized people.

There is a significant increase in the student of the various educational levels as specified in below Table 3-4 & 3-5

Table 3-4 Basic Education in Sudan, source Ministry of Education Sudan report (1999/2000).

Type of Education	Sudan				Greater Khartoum			
	No	Students			No	Students		
		Male	Female	Total		Male	Female	Total
Kindergarten (3 years)	7991	177004	172302	349306	1256	28925	29071	57996
Elementary School (8years)	11923	1696691	1440803	3137494	1367	345406	333444	678850
Secondary School (3years)	1694	207324	194100	401424	357	47454	50932	98386

Table 3-4 illustrates that most of the students concentrated in Greater Khartoum due to the lack of development in rural areas.

Table 3-5 Education Capacity in Sudan, source Report from Ministry of Education in Sudan for the year (2007/2008).

	Total Number in Sudan	Total students
Kindergartens	12000	450,000
Elementary School	13300	4,600,000
Secondary School	2500	600,000
Polytechnic School	120	44,000
University	27 (330 colleges)	300,000

Table 3-5 illustrates that there is a lacks of polytechnic schools although there is great needs for technicians in implementations of various development projects in Sudan.

3:4 Current Environmental Situations

The current environmental situations added to those specified in above sections will tackle natural forces, disposal system, infrastructures and pollutions in the study area as specified below:

3:4:1 Natural Forces

The natural forces are including both macro and micro climate characteristics such as the sun angles, temperature, wind directions, precipitation and relative humidity in the study area collected by the Sudan Meteorological Authority for thirty years (1971 - 2000) as specified below:

Table 3-6 illustrates the relative humidity, rainfall, evaporation, wind direction and wind speed as recorded in Khartoum Station at Lat (15, 36 N) and Long (32, 33E) - Alt: (380M).

Elem.	Relative Humidity (R.H.in %)	Rainfall in mm						Evapo. Piche (mm)	Wind	
Month	Mean	Total in mms	No of Rainy Days When Daily Rainfall > 0 mm			Maximum in one Day			Previous Direction	Means Speed m/ s
			0.1	1.0	10.0	Total	Date			
JAN	26	0.0	0.0	0.0	0.0	0.6	1/1/82	16.1	N	4.4
FEB	21	0.0	0.0	0.0	0.0	0	-	19.0	N	4.8
MAR	16	0.1	0.1	0.1	0.0	1.6	2/3/82	22.4	N	4.8
APR	15	0.0	0.0	0.0	0.0	Tr	-	24.5	N	4.4
MAY	20	3.9	0.9	0.7	0.1	15.1	30/5/87	22.7	N	4.0
JUN	26	4.2	0.9	0.6	0.1	27.5	3/6/83	21.8	SW	4.4
JUL	42	29.6	4.0	3.2	0.9	45.2	24/7/95	17.5	SW	4.8
AUG	48	48.3	4.2	3.3	1.4	200.5	4/8/88	15.2	SW	4.4
SEP	41	26.7	3.4	2.5	0.8	57.3	10/9/96	16.1	SW	4.0
OCT	29	7.8	1.2	0.8	0.2	40.2	7/10/97	18.5	N	3.5
NOV	26	0.7	0.0	0.0	0.0	22.2	1/11/76	19.1	N	4.4
DEC	29	0.0	0.0	0.0	0.0	0	-	16.0	N	4.4
YEAR	28	121.4	14.7	11.2	3.5	200.5	4/8/88	19.1	-	-

From Table 3-6 we can guess that the rainiest months are July, August and September with average annual contribution of 104.6 mms from the total annual rain 121.4 mms while the wind blows from the North except in June, July, August and September where it blows from South West SW.

Table 3-7 illustrates the air temperature and sunshine duration as recorded in Khartoum Station Lat: (15, 36 N) - Long (32, 33 E) - Alt: (380M)

Element	**Stat Level Press Mbar**	**Air Temperature in C**						**Mean Dry Temp (max+min) /2 in C**	**Bright Sunshine Duration**	
		Daily Maximum			**Daily Minimum**					
Month	HPA	Mean	HST	Date	Mean	LST	Date	In C	HRS	%
JAN	967.2	30.7	41.0	15/1/95	15.6	7.5	4/1/92	23.2	10.0	86
FEB	966.2	32.2	42.5	28/2/73 25/2/74	16.8	8.4	6/2/93	24.7	10.2	85
MAR	964.1	36.5	45.6	16/3/98	20.3	12.5	2/3/2000	28.4	9.9	82
APR	962.1	40.4	46.2	21/4/79	24.1	16.5	l/4/82 6/4/95	32.2	10.4	84
MAY	961.8	41.9	47.5	17/5/91	27.3	19.0	11/5/82	34.6	9.6	74
JUN	962.2	41.3	46.5	14/6/95	27.6	20.4	24/6/99	34.4	8.8	68
JULY	963.1	38.5	44.5	Sev.	26.2	17.8	31/7/82	32.3	8.1	63
AUG	963.4	37.6	43.5	18/8/86 25/8/90	25.6	18.0	26/8/72 21/8/92	31.6	8.5	66
SEP	963.1	38.7	45.3	29/9/97	26.3	16.0	7/9/95	32.5	8.8	71
OCT	963.2	39.3	43.0	3/10/90 1/10/97	25.9	17.5	31/10/77	32.6	9.7	83
NOV	965.4	35.2	41.0	1/11/80	21.0	11.0	12/11/82	28.1	10.3	91
DEC	967.0	31.7	39.0	15/12/83 7/12/90	17.0	6.2	19/12/71	24.4	10.1	90
YEAR	964.1	37.0	47.5	17/5/91	22.8	6.2	19/12/71	29.9	9.5	79

Table 3-7 illustrates there is no considerable variation in temperature between the different months because of the continuous shining of sun within the day. This characteristic can be usefully for producing solar energy in the study area.

3:4:2 Disposal Systems

Sewerage system in Greater Khartoum now is under the responsibility of Khartoum State Sewerage Corporation KSSC. Sewerage system in Greater Khartoum started in the early (1950s) by British company under the consultancy of Howard Hampered by the contractor Marbles Ridgway for the area between the Blue Nile and the Railway Station in Khartoum. The sewerage system extended in the early (1960s) to Amarat in Khartoum covered total area of 15 km^2 with total Asbestos pipe length of 250 km serving 80,000 of the population in Khartoum. In (1970) sewerage system service was established and extended to Khartoum Industrial Area for total area of 8.8 km^2.

The existing sewerage system in Greater Khartoum is just covering the following areas:

(i)	Khartoum CBD, Burri, Mogran	= 7.5 km^2
(ii)	Khartoum (2+3), Khartoum Industrial Area	= 4.3 km^2
(iii)	Amarat, Hai Alzhoor	= 2.5 km^2
(iv)	Khartoum Airport	= 0.8 km^2
	Total	= 15.1 km^2

This current situation illustrates the poor performance of the sewerage system in Greater Khartoum and particularly in our study. Therefore most of the population are used local drainage system composed of septic tanks and wells. This system causes pollutions and contaminations to the ground water and the Nile River Water.

The below Fig 3-1 illustrates the current disposal sewerage system in our study area and Greater Khartoum that reflects the poor situations of the sewerage disposal system in Greater Khartoum. This situation should be considered in the development plan in our study area.

Fig 3-1 the Existing drainage sewerage system in Greater Khartoum (source Khartoum State Sewerage Corporation KSSC)

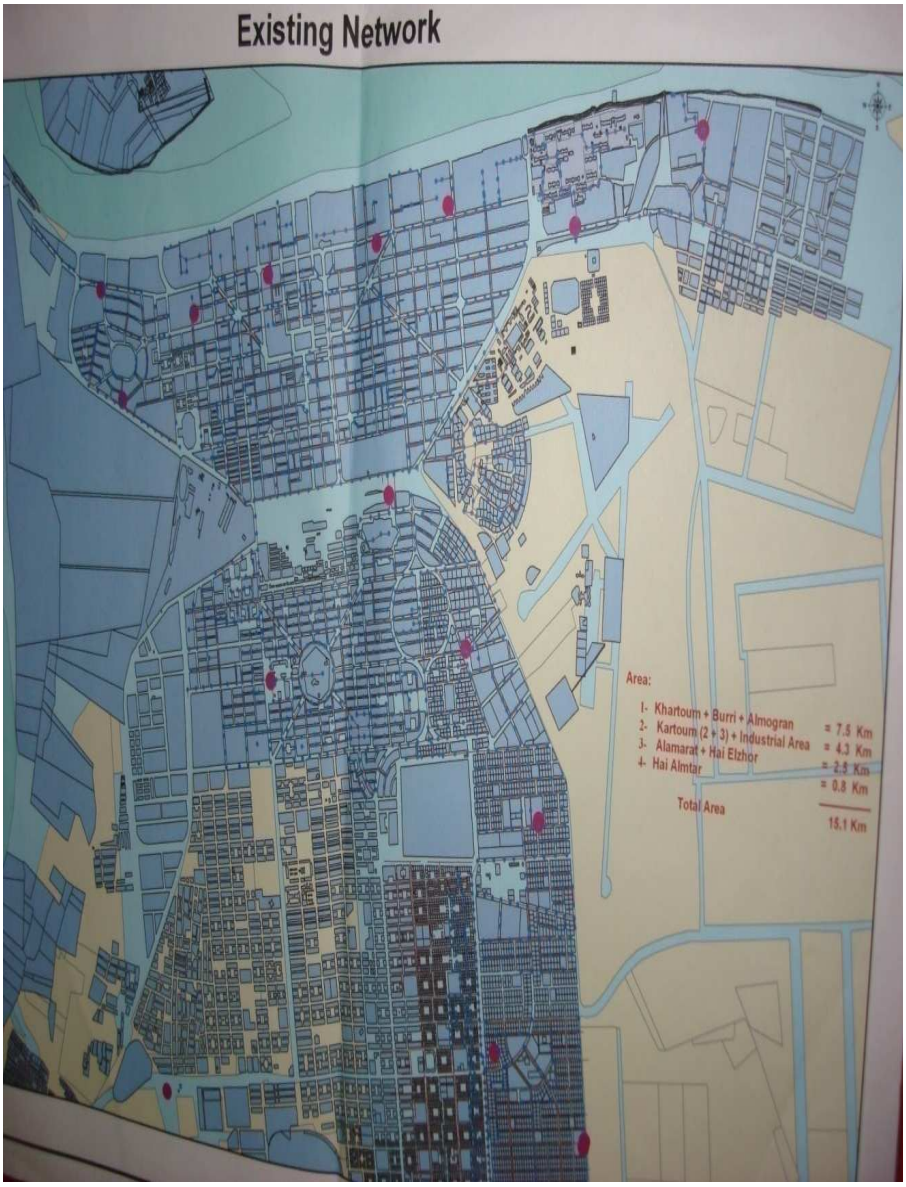


Fig 3-1 illustrates that the sewerage system constitutes a small area in Greater Khartoum and there is no sewerage system in Omdurman or Khartoum North.

3:4:3 Infrastructures

The study area as we specified represents the most important area in Greater Khartoum and acting as a heart for it and the whole country because all bridges and important roads that link the different areas of Greater Khartoum together and with the other towns in the country are located and passing through this important area.

The existing infrastructure beside those mentioned before will tackle the existing circulation system in Greater Khartoum, the existing bridges, the existing roads along the river front and transportation methods as specified below:

(i) On The Blue Nile we find the following bridges located in the study area Mak- Nimir, Old Khartoum North, Burri, Manshia Bridge and Tuti Bridge on the Left Branch of the Blue Nile.

(ii) On The White Nile we find the following bridges located in the study area Old Omdurman, Engaze and Salha which under construction and expected to be finished in (2011).

(iii) On The Main Nile we find Shambat Bridge.

(iv) The main railway line passing through Old Blue Nile Bridge.

(v) The main road along the river front in the study area is the Blue Nile Street in Khartoum with total asphalt street along the Blue Nile River of 9.5 km.

(vi) The second road in the study area is Aboroof Street along the Main Nile in Omdurman with total length of 5.25 km.

(vii) The only method of transportation between Tuti Island and Khartoum before the bridge was the ferry.

3:4:4 Pollution

Amount of pollution in our study area is varies according to the source and type of pollute as specified in below sections:

3:4:4:1 Pollution to the Nile River Water

Most of Sudanese people and their animals particularly in rural areas near the Nile River depend on their drinkable water from the river water without treatments therefore there should be a significant consideration to the Nile River water from any source of pollutions so as not to cause diseases to those poor people or to their animals. In spite of the need for pure Nile River water for the population and animals there are some of pollutant sources to the Nile River water in Greater Khartoum as summarized below:

(i) Pollution from Khartoum North Water Station on the Blue Nile such as oils, grease, chemical disposal.

(ii) Pollution occurs from Burri for Electrical and Water Station on the Blue Nile which estimated by 5% from the total production which is 1000 M^3/ day.

(iii) Pollution from military area in Khartoum North and from Kobar National Prison on the Blue Nile in sort of oils, refuse disposals and chemicals.

(iv) Pollution from the restaurants and cafeterias along the Blue Nile in Khartoum and along the Main Nile in Omdurman such as disposals, drainage and oils.

(v) Pollution from Industrial area in Khartoum along the White Nile such as Saria, workshops, military factory in Shagra.

(vi) Pollution from Military Hospital in Omdurman along the white Nile

(vii) Pollution from Water Station at North Omdurman on the Main Nile River in a sort of oils, Greases, chemical polymer.

(viii) Pollution from the restaurants in Almorada and Rivera parks in Omdurman along the Main Nile River.

3:4:4:2 Types of pollution in the Nile River

Types of pollution in the study area depends on the source pollutant and from the chemical analysis by UNESCO Chairs in Water Resources in Khartoum for the Nile River in Greater Khartoum (August 2002 p.112) the main types of pollution are oil and grease OG, Nitrates NO^2,

dissolved oxygen DO, Bio- chemical oxygen demand BOD, chemical oxygen demand COD. Amount of these pollutions are specified in Table 3-8.

Table 3-8 Amount and Types of Pollutions in Nile River source UNESCO Chairs in Water Resources in Khartoum (August 2002 volume 5 p. 112)

Item	Location	DO Mg/lit	BOD Mg/lit	COD Mg/lit	O&G Mg/lit	NO^2 Mg/lit	Gr +6
1	Khartoum North Water Station- Blue Nile	6.5	6.5	14.3	231	0.21	NA
2	Friendship Hotel-Blue Nile (BN)	6.5	7.7	12.8	179.2	0.30	Na
3	Burri Electrical and Water Station BN	6.5	5	30.9	237.6	0.27	NA
4	Restaurants and Cafeterias along BN	6.5	6.5	33.3	227.2	0.05	NA
5	Sunut Forest White Nile WN	6.7	3.5	32.9	100.4	Nil	NA
6	Military Hospital WN	6.7	3	30.9	234	Nil	NA
7	Khartoum Industrial Area WN	NA	NA	NA	NA	NA	0.42*
8	Omdurman Water Station MN	7.9	3.5	30.5	108.4	Nil	NA
9	Almorada restaurants Main Nile MN	7.9	3	39.5	95.6	Nil	NA

3:4:4:3 Pollution from Local Sanitation System

Lack and absent of sewerage disposal system in Greater Khartoum lead people to use boreholes and septic tank located in residential, commercial or industrial areas as local disposal system. This local drainage system lead to pollute ground water because these boreholes or wells are excavated till the water level which ranging between 15 to 40 m deep in Greater Khartoum. The polluted ground water caused pollution to the Nile River Water.

3:4:4:4 Pollutions from Cars

The study area is a heart of Greater Khartoum and Sudan which dominate major traffic of the population in the three cities Khartoum, Khartoum North and Omdurman that form Greater Khartoum. These cars are passing the three rivers Blue, White and Main Nile through seven constructed bridges that polluted the air by CO^2 occur from these passing cars, particularly the CO^2 from cars is increasing due the congestion at these seven bridges along the three rivers as

they are the only crossing points between these cities. Part of the CO^2 is dissolved in the Nile River water that caused pollution to river water.

3:5 Location and Divisions of the Study Area

The location of the study area extends from Manshia Bridge on the Blue Nile at the Eastern side of the study area, Salha Bridge on the White Nile at the Southern side of the study area, Khor-Elnaim and University of Khartoum College of Agriculture at the north of Shambat Bridge on the River Nile at the Northern side of the study area. The total length of the study area is 67.875 km. The study area will be divided into sixteenth shores for the following reasons:

- There is previous study carried in (2002) by UNESCO Chair in Water Resources in Sudan for the hydraulic and river pattern system in the centre of Khartoum. This study divided the Nile River to 12 Shores. These shores are extended from Burri Bridge to the North of Shambat Bridge with total length of 36.875 km. The division of these shores in this study is based on the existing bridges on the Nile River, where each shore extended from bridge to another bridge. The study divided the shores between these existing bridges into 9 shores and adding to them the three shores of Tuti Island, so they become 12 shores.
- There are another four shores that will be considered in this study with total length of 31.00 km, because of the new constructed bridges after that study carried in (2002) on the Nile River in Khartoum.
- These additional four shores are of high potential and facing the most urban areas in Greater Khartoum such as Garden City, Burri, Shagra, Fithab, Sunut Forest, Salha etc.
- The division of the Nile River into 16 Shores in this study is covered all the Nile River Shores extended between the existing bridges in Greater Khartoum.
- These 16 Shores tackles the six frontages of the Nile River in Greater Khartoum. The six frontages are the two frontages of the Blue Nile that facing Khartoum and Khartoum North, the two frontages of the White Nile that facing Khartoum and Omdurman and the two frontages of the Main Nile that facing Omdurman and Khartoum North.

For the purpose of this study we define shore as the area extended between the water line of the main stream and the main road along the river such as the Blue Nile Street, or that area located between the main stream and the river front. While river front can be defined as that area extended along the river shore and connected visually with the river. The river front can easily be seen from the main stream and the river shore without constraints or obstacles.

These shores are extended along the Blue Nile, the White Nile, the Main Nile River and the confluence of the Blue and White Nile at Tuti Island as illustrates in Fig 3-2.

Fig 3-2 Divisions of the Study Area to 16 Nile River Shores (source Survey Department Khartoum)

Fig 3:2 illustrates that the 16 Nile River Shores and their Riverfronts in the study area are divided to:

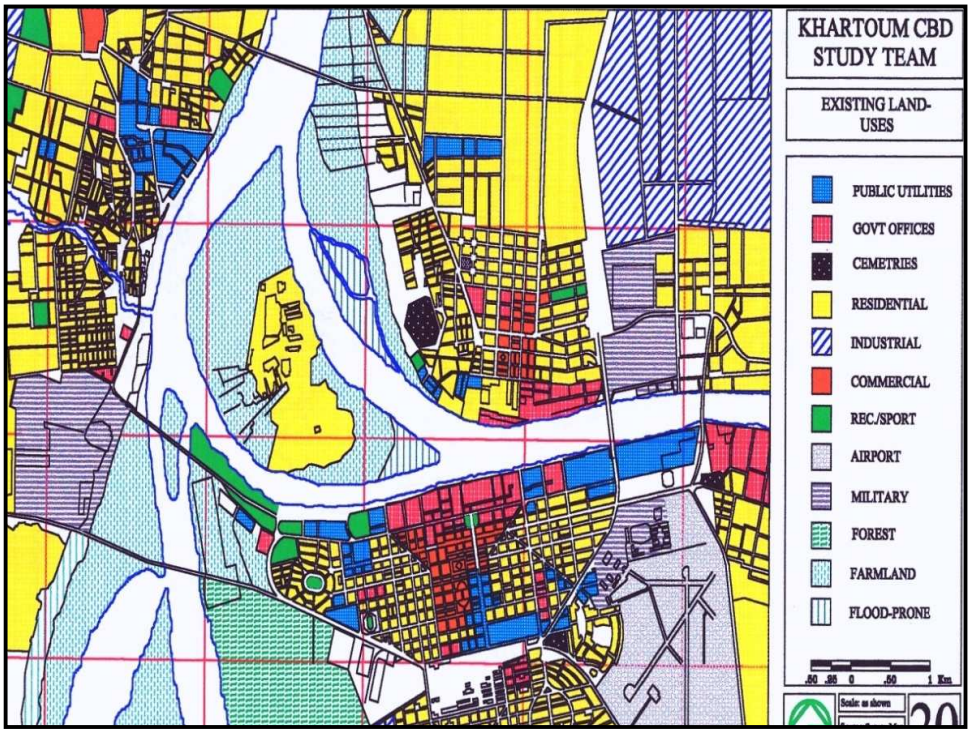
- 6 Shores on the Blue Nile numbered 1, 2, 3, 6, 13 and 14.
- 4 Shores on the White Nile numbered 7, 8, 15 and 16.
- 3 Shores on the Main Nile numbered 9, 11, and 12.
- 3 Shores of Tuti Island numbered 4, 5, and 10.

Survey will be taken for the 16 Nile River Shores and the frontages of those Shores that known with Riverfronts. The information from the survey results for each Nile River Shore and its Riverfront with illustrations and photos will be collected. The collected information incorporated with those collected in chapter two about the hydrology of the Nile River will be used in the analysis process for suitable stabilization methods for each Nile Bank and development of the Nile Riverfronts in Greater Khartoum.

3:6 Survey Results of the Existing Land Uses in the Study Area

There are many and varied uses of the lands within the study area. These include governmental, commercial, residential, agricultural, industrial, disposal, services and other land uses areas as illustrates in Fig 3-3.

Fig 3-3 Existing Land Uses source the final report of Khartoum CBD Study Team (July 1999 p.19)



From Fig 3-3 the Nile River Shores and Nile River Fronts composed of various land uses as summarized in Table 3-9.

Table 3-9 Types of Existing Land Uses of Nile River Shores and River Fronts

Shore & River Front Number	Length in meters	Land Uses								Note
		Flood Plain / Acres	Agriculture / Acres	Industrial of Red Bricks/ Acres	Recreational Types	Residential Types	Commercial Types	Forest \ Acre	Public Building Types	
1	3000	40	40	-	Sport Club	-	-	-	Education, Offices	
2	3000	-	-	-	Blue Nile Casino	Military Housing	_	-	-	
3	4000	-	-	-	Parks, Theatre, Cinema	-	Khartoum CBD Area	-	Gov. Offices Ministries, Public Palace	Most of Governmental Building
4	3500	720	400	50	-	Housing	-	-	-	Area of Tuti
5	3875	720	400	50	-	Housing	-	-	-	Area of Tuti
6	4250	100	80	20	Hotel	Housing	-	-	-	
7	1250	145	-	-	-	-	New CBD for Africa	-	-	Under Construction
8	1250	88	88	-	-	Housing	-	-	Military Hospital	
9	3750	70	65	5	Parks	Villas, Housing, Flats	Offices, Markets, Restaurants	-	House of Parliament	
10	3000	720	400	50	-	Housing	-	-	-	Area of Tuti
11	3000	200	175	25	-	Villas, Housing	-		Agriculture College	
12	3000	70	60	10	-	Housing	Market		-	
13	4500	150	120	30	-	Villas, Housing	Flats, Restaurants		Water Station	
14	4500	200	160	40	-	Housing	-		-	
15	11000	360	-	-	-	Housing	-	360	-	Sunut Forest
16	11000	900	900	-	-	Housing	-		-	

Table 3-9 illustrates that the 16 shores in the study area are containing total floodplain area of 3043 Acres except Shore 2 and 3 are without floodplain area. The floodplain area is used in agriculture with total area of 2088 Acres and local industry for mud red bricks with total area of 180 Acres.

Adding to above information the below sections specified the general characteristics and information illustrates with photos from the survey results for those 16 shores and their riverfronts on the Blue Nile, White Nile, Main Nile and Tuti Island.

3:7 Blue Nile Survey Results

The survey for the Blue Nile is covered the six Blue Nile Shores and the six Riverfronts along them. These six Shores and Riverfronts of the Blue Nile numbered 1, 2, 3, 6, 13 and 14. They extended from Manshia Bridge to the confluence of the Left branch of the Blue Nile with White Nile at Mogran or White Nile Bridge. Blue Nile shores and their riverfronts are facing Khartoum and Khartoum North with total length of 23.250 km as illustrates in Fig 3-4

Fig 3-4 Blue Nile Shores and Riverfronts source Survey Department Khartoum

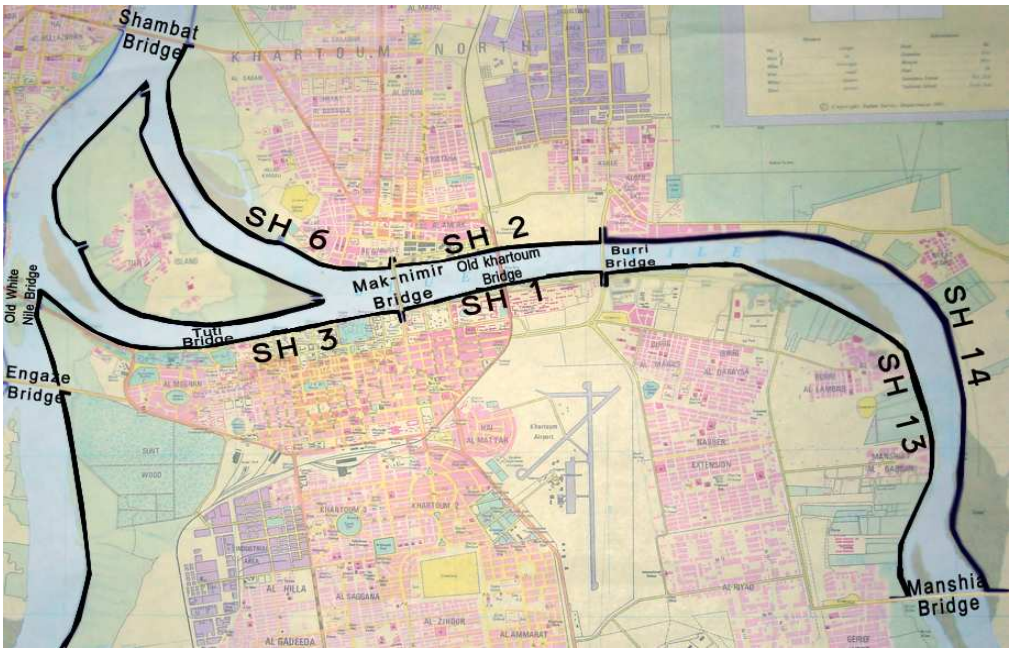


Fig 3:3 of the Blue Nile Shores and their Riverfronts illustrates that Shore 1, 3 and 13 are facing Khartoum with total length of 11.500 km and Shore 2, 6 and 14 are facing Khartoum North with total length of 11.75 km. The information about the characteristics and specifications for those six Shores on the Blue Nile and the Riverfronts facing those Shores from the survey results are specified in Table 3-10.

Table 3-10 illustrates the Survey Results of the Blue Nile Shores and their Riverfronts (source the author).

Description	**Shore & Riverfront 1**	**Shore & Riverfront 2**	**Shore & Riverfront 3**	**Shore& Riverfront 6**	**Shore & Riverfront 13**	**Shore & Riverfront 14**
Location of the Shore and its Riverfront	Burri Bridge to Mak Nimir Bridge facing Khartoum	Burri Bridge to Mak Nimir Bridge facing Khartoum North	Mak Nimir Bridge to Old White Nile Bridge facing Khartoum	Mak Nimir Bridge to Shambat Bridge facing Khartoum North	Burri Bridge to Manshia Bridge facing Khartoum	Burri Bridge to Manshia Bridge facing Khartoum North
Length of the Shore & its Riverfront in meter	3000 m	3000 m	4000 m	4250 m	4500 m	4500 m
Area of Floodplain	40 acre	None	None	100 acre	150 acre	200 acre
Floodplain land uses	Agriculture for fruits and vegetables	None	None	Agriculture & Industry of Red Mud Bricks	Agriculture & Industry of Red Mud Bricks	Agriculture & Industry of Red Mud Bricks
Land ownership	Governmental & Private	Governmental (Gov)	Gov	Gov & Private	Gov & Private	Gov & Private
Existing Protection	None	None	Masonry & BrickWalls	None	None	None

Description	**Shore & Riverfront 1**	**Shore & Riverfront 2**	**Shore & Riverfront 3**	**Shore& Riverfront 6**	**Shore & Riverfront 13**	**Shore & Riverfront 14**
Bank Soil Type	Clay	Clay	Clay	Sandy Clay Loam	Clay Loam	Clay Loam
Bank Stability	Unstable	Unstable	Stable	Unstable	Unstable	Unstable
Accessibility to River Shore	Accessible by Asphalt Street	None	Accessible by Asphalt Street	None	Partially Accessible	None
Length of Asphalt Street in Km	3 Km	None	4 Km	None	2.5 Km	None
Important Buildings on Riverfront	1-University of Khartoum. 2-Ministry of: Education, Health and Irrigation. 3- Office Buildings.	1-Military Buildings. 2- Kobar Prison. 3- Private Buildings	1- Khartoum CBD Area 2- Public Palace. 3- Gov Buildings. 4- Fatih Tower	Private Housing Buildings	Private Villas and Housing Buildings	Private Housing Buildings
Recreational Facilities	1- Blue Nile Sport Club. 2- Tourist Restaurant. 3- Physician Club	1- Blue Nile Casino	1- Friendship Hall. 2- Public Garden. 3- Parks. 4- Hotels	1- Friend Ship Hotel.	None	None
Storey Height of Riverfront Buildings	2 - 12	1-3	5-20	1- 12	2- 5	1-3
Panoramic View of Riverfront	Different Height	Regular Low Height	Different Height	Different Height	Regular Medium Height	Regular Low Height

From Table 3-10 it can be seen that with the exception of shore 3 none of the other shores have protection banks, most of the bank soil is clay, the floodplain is used in agriculture and the land ownership is private or governmental. More illustrations by survey photos for those Blue Nile Shores and their Riverfronts are shown in the next sections.

3:7:1 Shore and Riverfront 1

This Shore and its Riverfront is facing Khartoum. It contains floodplain area and without protection bank, while the Riverfront contains buildings of different height and Asphalt Street along the Blue Nile. The general condition of this shore and its riverfront illustrates by the below photo number 3-1, 3-2, 3-3 and 3-4.

Photo 3-1 Photograph showing floodplain area of Shore 1 (source the author)

Photo 3-2 Photograph showing that the bank of Shore 1 has no stabilization (source the author)

Photo 3-3 Photograph showing the good accessibility to the shore by Blue Nile Asphalt Street (source the author)

Photo 3-4 Photograph showing the Nile River Road (source the author)

3:7:2 Shore and Riverfront 2

This Shore and its Riverfront is facing Khartoum North without stabilization bank and floodplain. The Shore is not accessible and most of the buildings are military. The general condition of the Shore and the Riverfront along this Shore as shown in photo number 3-5 and 3-6

Photo 3-5 Photograph showing the bank of Shore 2 is without sustainable stabilization and the riverfront is not accessible (source the author)

Photo 3-6 Photograph showing the river front contains low building height and not accessible (source the author)

3:7:3 Shore and Riverfront 3

This Shore and the Riverfront along it is facing Khartoum Business District CBD area and accessible by Asphalt Street. The shore is stabilized with Masonry and Bricks Walls. The Riverfront along this shore contains most of important governmental, recreational and historical buildings that constructed in the nineteenth century within Turkish and English-Egyptian Period. The characteristic of this Shore and the Riverfront along it is as shown by photos number 3-7, 3-8 and 3-9.

Photo 3-7 Photograph showing the bank of Shore 3 stabilized with masonry and bricks walls (source the author)

Photo 3-8 Photograph showing the Asphalt Nile Street and the important building such as Fatih Tower (source the author)

Photo 3-9 Photograph showing the 6 April Public Park (source the author)

3:7:4 Shore and Riverfront 6

This Shore and the Riverfront along it is facing Khartoum North. It is without banks protection and contains large floodplain area used in agriculture and industry of local red mud bricks. The Shore is without accessibility to the river. It contains low rise building except Friendship Hotel Palace as illustrates in photos number 3-10 and 3-11.

Photo 3-10 Photograph showing the bank of Shore 6 has no protection and the Friendship Hotel Palace (source the author)

Photo 3-11 Photograph showing Mak Nimir Bridge between Shore 2 and 6 (source the author)

3:7:5 Shore and Riverfront 13

This Shore and the Riverfront along it is facing Khartoum. The shore is without protection but, it is partially accessible by Asphalt Street. The shore contains large floodplain area used in agriculture and red mud bricks industry. The Riverfront along Shore 13 contains most of the

valuable residential areas in Greater Khartoum such as Garden City, Manshia and Burri. The Riverfront also on which we find the high rise building in Sudan that the Communication Tower. The general conditions of this Shore and its Riverfront is as shown by photos number 3-12, 3-13, 3-14 and 3-15.

Photo 3-12 Photograph showing the bank Shore 13 has no stabilization wall (source the author)

Photo 3-13 Photograph showing the red mud brick industry adjacent to Shore 13 (source the author)

Photo 3-14 Photograph showing the Communication Tower as the highest high rise building in the Sudan comparing to other buildings on Riverfront 13 (source the author)

Photo 3-15 Photograph showing the accessible part of Shore 13 by Asphalt Street and the valuable villas at this Riverfront 13 (source the author)

3:7:6 Shore and Riverfront 14

This Shore and the Riverfront along it is facing Khartoum North. The Shore is without banks protection and contains large floodplain area adjacent to Manshia Bridge that used in agriculture and industry of red mud bricks. The Riverfront adjacent to Shore 14 contains low cost housing

and is without accessibility to the River. A photo number 3-16 and 3-17 illustrates the general conditions of this Shore and the Riverfront adjacent to it.

Photo 3-16 Photograph showing Shore 14 containing large floodplain area and without stabilization banks (source the author)

Photo 3-17 Photograph showing the large floodplain area that is used in agriculture and manufacturing of red mud bricks adjacent to Shore 14 and the low rise buildings on Riverfront 14 (source the author)

3:8 White Nile Survey Results

The survey of the White Nile is covered the four White Nile Shores and the Riverfronts facing these Shores. They extended from Old White Nile Bridge at Mogran to Salha Bridge. They are facing Khartoum and Omdurman with total length of 24.500 km. These Shores and Riverfronts along them numbered 7, 8, 15 and 16 as illustrates in Fig 3-5.

Fig 3-5 of the 4 White Nile Shores and the Riverfronts along them illustrates that Shore 7 and 15 are facing Khartoum with total length of 12.250 km, Shore 8 and 16 are facing Omdurman with total length of 12.250 km and they are containing large floodplain areas.

The general information about the characteristics and specifications from the survey results for these four Shores on the White Nile and the Riverfronts adjacent to these Shores are specified in Table 3-11.

Fig 3-5 White Nile Shores source Survey Department Khartoum

Table 3-11 Survey results for the four White Nile Shores and the Riverfronts adjacent to them (source the author)

Description	Shore & Riverfront 7	Shore & Riverfront 8	Shore & Riverfront 15	Shore & Riverfront 16
Location of the Shore and its Riverfront	Old Nile Bridge to Engaze Bridge facing Khartoum	Old Nile Bridge to Engaze Bridge facing Omdurman	Engaze Bridge to Salha Bridge facing Khartoum	Engaze Bridge to Salha Bridge facing Omdurman
Length of the Shore and its Riverfront in meter	1250 m	1250 m	11000 m	11000 m
Area of Floodplain	145 acre	88 acre	360 acre	900 acre
Floodplain land uses	Planning for New CBD area for Africa by Sunut Company	Agriculture for vegetables	Sunut Natural Forest	Agriculture for vegetables
Land ownership	Governmental	Private and Governmental	Governmental	Private and Governmental
Existing Protection	Masonry Walls on dry pitching earth embankments	None	None	None
Bank Soil Type	Sandy Clay Loam Soil	Sandy Clay	Sandy Clay	Sandy Clay
Bank Stability	Stable	Unstable	Unstable	Unstable
Accessibility to River Shore	None	None	None	None
Length of Asphalt Street in Km	None	None	None	None
Important Buildings on Riverfront	1- New CBD are for Africa under Construction	1- Military Hospital. 2- Housing Buildings.	1- Private Residential Buildings. 2- Military Camps	1- Rural Residential Area. 2-
Recreational Facilities	None	None	Sunut Natural Forest	None
Storey Height of Riverfront Buildings	10-25	1-7	1-3	One Storey Rural Housings
Panoramic View of Riverfront	Regular High Height	Different Height	Regular Low Height	Regular Low Height

From Table 3-11 it can be seen that Shore 7 is protected with masonry on dry pitching on compacted earth embankments, the other three shores have no protection, the floodplain is used in agriculture and the protective Shore 3 will be used for new CBD area for Africa. The general characteristics of these Shores and the Riverfronts along them are shown by the survey photos in the next sections.

3:8:1 Shore and Riverfront 7

This Shore and its Riverfront is facing Khartoum with large floodplain area planned for new development that is the CBD area for Africa by Sunut Company. The shore is protected by Masonry Walls on dry pitching earth embankments. The shore is not accessible. The general characteristic of Shore 7 and its Riverfront from the survey results is shown by photos, 3- 18, 3-19, 3-20 and 3-21.

Photo 3-18 Photograph showing there is no accessibility to Shore 7 (source the author)

Photo 3-19 Photograph showing the bank of Shore 7 is stabilized with masonry walls on dry pitching earth embankments (source the author)

Photo 3-20 Photograph showing the new CBD area for Africa under construction (source the author)

Photo 3-21 Photograph showing the panoramic view of Riverfront 7 (source the author)

3:8:2 Shore and Riverfront 8

Shore 8 and the Riverfront adjacent to it are facing Omdurman. The Shore is not accessible from the Riverfront along it and it is without banks protection. The Shore contains large floodplain areas used in agriculture and part of this Shore is under development. Most of the buildings on the Riverfront facing Shore 8 are private low costing housing except the Military Medical Hospital. The general characteristics of Shore 8 and the Riverfront adjacent to it from the survey results is shown by photos, 3-22, 3-23, 3-24 and 3-25.

Photo 3-22 Photograph showing the bank of Shore 8 without stabilization (source the author)

Photo 3-23 Photograph showing the bank of Shore 8 contains large floodplain area used in agriculture (source the author)

Photo 3-24 Photograph showing River Front 8 is without accessibility but it is under development (source the author)

Photo 3-25 Photograph showing the low cost housing except Military Medical Hospital on River Front 8 (source the author)

3:8:3 Shore and Riverfront 15

Shore 15 and the Riverfront adjacent to it is the long shore in this study. The Shore and its Riverfront are facing Khartoum with a total length of 11.00 km. The Shore is without banks protection or accessibility to the Riverfront. The Shore contains the Natural Sunut Forest as natural conservation area in Greater Khartoum. The Riverfront adjacent to Shore 15 contains low cost housing, military industries and scatter settlements. The general characteristics of Shore 15 and the Riverfront adjacent to it from the survey results are shown in photos 3-26, 3-27, 3-28 and 3-29.

Photo 3-26 Photograph showing the Natural Sunut Forest on Shore 15 (source the author)

Photo 3-27 Photograph showing Shore 15 is without accessibility and the bad use in the Sunut Natural Forest (source the author)

Photo 3-28 Photograph showing the scatter settlement on the Riverfront adjacent to Shore 15 (source the author)

Photo 3-29 Photograph showing Riverfront adjacent to Shore 15 is without accessibility or infrastructures (source the author)

3:8:4 Shore and Riverfront 16

Shore 16 with the Riverfront adjacent to it is with the same length of Shore 15 but it is facing Omdurman. The Shore is without banks protection or accessibility to the river. It contains large floodplain area used in agriculture. The Riverfront adjacent to Shore 16 contains low cost rural housing and without accessibility or infrastructures. The general characteristics of Shore 16 and the Riverfront adjacent to it from the survey results are shown by photos 3-30, 3-31, 3-32 and 3-33.

Photo 3-30 Photograph showing the banks of Shore 16 has no stabilization and the piers of Salha Bridge under construction (source the author)

Photo 3-31 Photograph showing the earth embankments on Shore 16 that used by native settlements to protect their housing from flood (source the author)

Photo 3-32 Photograph showing the rural settlements on the Riverfront adjacent to Shore 16 constructed from mud walls and they used earth embankment to protect their housing (source the author)

Photo 3-33 Photograph showing the rural characteristic of Shore 16 and the Riverfront adjacent to it and the large floodplain area at this Shore (source the author)

3:9 Main Nile River Survey Results

The Main Nile River Shores and the Riverfronts adjacent to them are divided to three Shores. They extended from the Old White Nile Bridge at the confluence of the Blue and White Nile to University of Khartoum Agriculture College and Khor-Elnaim at the North of the Shambat Bridge. Shore 9 and 12 are facing Omdurman with total length of 6.750 km, while Shore 11 is facing Khartoum North with total length of 3.000 km as illustrates in Fig 3- 6.

Fig 3-6 Main Nile River Shores source Survey Department Khartoum

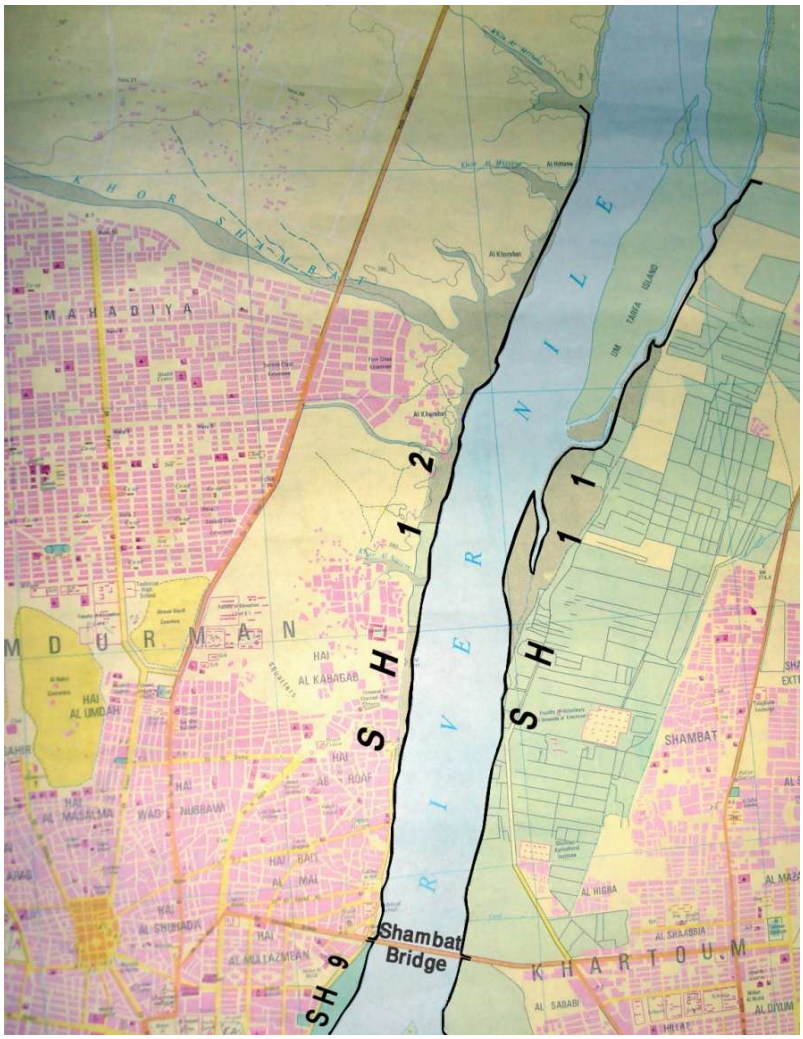


Fig 3-6 of the 3 Main Nile River Shores and the Riverfronts adjacent to them illustrates that the banks of these Shores have no protection except 1.250 km and the Shores contain large floodplain area used in agriculture and industry of local red mud bricks. The Riverfronts adjacent to them composed of recreational and residential buildings. The general characteristics and specifications of these Shores and the Riverfronts adjacent to them from the survey results are specified in Table 3-12.

Table 3-12 Survey results for the 3 Main Nile River Shores and the Riverfronts adjacent to them (source the author)

Description	**Sore 9**	**Shore 11**	**Shore 12**
Location of the Shore and its Riverfront	Old White Nile Bridge to Shambat Bridge facing Omdurman	Shambat Bridge to University of Khartoum Agriculture College facing Khartoum North	Shambat Bridge to Khor-Elnaim facing Omdurman
Length of the Shore and its Riverfront in meter	3750 m	3000 m	3000 m
Area of Floodplain in acres	70 acres	200 acres	70 acres
Floodplain land use	Agriculture and Industry of Mud Bricks	Agriculture and Industry of Mud Bricks	Agriculture and Industry of Mud Bricks
Land ownership	Private	Private	Private
Existing Bank Protection	1250 m protected with Masonry and Brick Walls and the remaining Shore has no protection	None	None
Soil Type	Clay Loam	Clay Loam	Clay Loam
Stability	1250 m Stable + 2500 m Unstable	Unstable	Unstable
Accessibility to River Shore	Accessible by Asphalt Street	None	1500 m Accessible by Asphalt Street + 1500 m Accessible by Earth Street.
Length of Asphalt Street in km	3.75 km	None	1.5 km + 1.5km Earth Street

Description	Sore 9	Shore 11	Shore 12
Important Buildings on Riverfront	House of Parliament, Radio and Television Centre, Schools, Hospital and Private Housing	University of Khartoum Agriculture College and Private Housing	Private Housing and Water Station
Recreational Facilities	Parks, Sudan Main Theatre, Casino and Concert Halls.	None	None
Storey Height of Riverfront Buildings	3-10	1-3	2-5
Panoramic View of Riverfront	Different Height	Regular Low Height	Regular Medium Height

From Table 3-12 it can be seen that the floodplain land is private, the land of the floodplain is used in agriculture and industry of red mud bricks and there are different uses of the Riverfronts areas. The general conditions of these three Shores and the Riverfronts adjacent to them from the survey photos results are shown in below sections.

3:9:1 Shore and Riverfront 9

Shore 9 and the Riverfront adjacent to it are extended from Old White Nile Bridge to Shambat Bridge. The Shore is facing Omdurman with total length of 3.750 km. The Shore contains large floodplain area used in agriculture and industry of mud red bricks. The Riverfront adjacent to this Shore contains most of recreational facilities on the stable part of it. The general conditions of this Shore and the Riverfront adjacent to it is as shown from the survey results in photos 3-34, 3-35 and 3-36.

Photo 3-34 Photograph showing the stabilized part of Shore 9 and the large floodplain area used for agriculture (source the author)

Photo 3-35 Photograph showing the unstable part of Shore 9 (source the author)

Photo 3-36 Photograph showing the public park on River Front 9 (source the author)

3:9:2 Shore and Riverfront 11

Shore 11 and the Riverfront adjacent to it extended from Shambat Bridge to University of Khartoum Agriculture College. The Shore is facing Khartoum North with total length of 3.000 km. The Shore Contains large floodplain area used in agriculture and industry of red mud bricks. The Shore is not accessible from the Riverfront. The general conditions of this Shore and the Riverfront adjacent to it from the survey results are as illustrates in photos 3-37, 3-38 and 3-39

Photo 3-37 Photograph showing the bank of Shore 11 contains large floodplain area used in agriculture and the banks of this Shore are without protections (source the author)

Photo 3-38 Photograph showing the used of industry of red mud brick on Shore 11 (source the author)

Photo 3-39 Photograph showing the agriculture area on River Front 11 (source the author)

3:9:3 Shore and Riverfront 12

Shore 12 and the Riverfront adjacent to it extended from Shambat Bridge to Khor- Elnaim. The Shore is facing Omdurman with total length of 3.000 km. It contains large private floodplain area used in agriculture and industry of red mud bricks. Part of this Riverfront is accessible with Asphalt Street while the other is accessible with Earth Street. The general conditions of this Shore and the Riverfront adjacent to it from the survey results are shown in photos 3-40, 3-41, 3-42 and 3-43.

Photo 3-40 Photograph showing the bank of Shore 12 is without sustainable stabilization method (source the author)

Photo 3-41 Photograph showing the used of red mud brick industry on Shore 12 (source the author)

Photo 3-42 Photograph showing the accessible part of River Front 12 by Asphalt Street (source the author)

Photo 3-43 Photograph showing the remaining part of River Front 12 is accessible by Earth Street (source the author)

3:10 Confluences Survey Results at Tuti Island

The confluences of the Blue and White Nile composed of the three shores at Tuti Island with total length of 10.375 km. Tuti Island is a crescent shaped island built up as a result of mud sedimentation on sedimentation rocks during flood season as illustrates in Fig 3-7

Fig 3-7 Confluences Shores and Riverfront adjacent to them at Tuti Island source Survey Department Khartoum

Fig 3-7 illustrates that the three Shores have no banks protections, without accessibility to the Riverfronts and without infrastructures. The general specifications and characteristics of these three Shores and the Riverfronts adjacent to them at Tuti Island from the survey results are illustrates in Table 3-13.

Table 3-13 Survey results for the confluences Shores and the Riverfronts adjacent to them at Tuti Island (source the author)

Description	Shore 4	Shore 5	Shore 10
Location of the Shore and its Riverfront	Eastern side to the Southern side of the Island facing Khartoum	Eastern side to the Northern side of the Island facing Khartoum North	Southern side to the Northern side of the Island facing Omdurman
Length of the Shore and its Riverfront in meter	3500 m	3875 m	3000 m
Area of Floodplain in acres	243 acres	269 acres	208 acres
Floodplain land uses	Agriculture and Industry of Mud Bricks	Agriculture and Industry of Mud Bricks	Agriculture and Industry of Mud Bricks
Land ownership	Private	Private	Private
Existing Bank Protection	None	None	None
Soil Type	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
Stability	Unstable	Unstable	Unstable
Accessibility to Shore	None	None	None
Length of Asphalt Street in Km	None	None	None
Important Buildings on Riverfront	1-Panton Station. 2- Low Cost Private Housing.	1- Agricultural Farms. 2- Industry for Mud Bricks	1- Agriculture Farms. 2- Industry for Mud Bricks
Recreational Facilities	None	None	None
Storey Height of Riverfront Buildings	One Storey Low Cost Private and Governmental Buildings	None	None
Panoramic View of Riverfront	Regular Low Height	Different Agricultural Trees	Different Agricultural Trees

Table 3-13 illustrates that, the three shores have no protections, all the land is private and they have no infrastructures. The general conditions of these Shores and the Riverfront adjacent to them from the survey results are shown by photos in below sections.

3:10:1 Shore and Riverfront 4

Shore 4 and the Riverfront adjacent to it is facing Khartoum on the Left Branch of the Blue Nile with total length of 3.500 km. It has no protection and without accessibility to the Riverfront. Local transportation is used to Khartoum with Pantoon before the construction of Tuti Suspended Bridge. The general conditions of this Shore and the Riverfront adjacent to it from the survey results are shown in photos 3-44 and 3-45.

Photo 3-44 Photograph showing method of accessibility to the island by Panton (source the author)

Photo 3-45 Photograph showing Tuti Suspended Bridge to Khartoum (source the author)

3:10:2 Shore and Riverfront 5

Shore 5 and the Riverfront adjacent to it are facing Khartoum North on the Right Branch of the Blue Nile with total length of 3.875 km. It is without protection and not accessible as illustrates in photo 3-46.

Photo 3-46 Photograph showing the bank without stabilization or infrastructures (source the author)

3:10:3 Shore and Riverfront 10

This third shore of Tuti Island is facing Omdurman with total length of 3.000 km. Shore 10 has no stabilization banks and without accessibility as illustrates in photo 3-47.

Photo 3-47 Photograph showing the eroded banks of Shore 10 has no stabilization (source the author)

3:11 Summary of Chapter Three

Chapter three presented the survey results of the current situations of the study area. The surveyed issues indicated in this chapter were covered:

i. Drives of development in the study area that indicated the potentialities of this valuable area in Greater Khartoum.

ii. General and economic structures of Sudan economy, which indicated various resources and economic growth of Sudan. The survey of the economic issues was presented for they will be required in the implementation process of a development programme for the Nile River Front at Greater Khartoum.

iii. Environmental and social situations related to demographic characteristics of Sudan and the study area, public services, infrastructures and pollution in the study area. The presentation of these issues from the survey results for the current situation of the study area will be used in the plan making process of a development plan for the study area.

iv. Location and divisions of the study area into 16 manageable zones or Nile River Shores included the adjacent land to them. These Shores extended on Blue, White, Main Nile River and the confluences of the Blue and White Nile at Tuti Island. The survey results for the 16 Nile Shores and the land adjacent to them or Riverfronts were presented and illustrates with photos to indicate the current specifications and conditions of these Shores and Riverfronts in the study area.

The presentation of these surveyed issues for the current situation of the study area is providing a guideline and base-line information that required for the options of the methods of stabilizing each of the 16 Nile River Banks so as development can take place safely on the Nile River Front at Greater Khartoum.

CAPTER FOUR: THEORETICAL BACKGROUND

4:0 Introduction

Chapter Four will tackle the general literature review about sustainable development. The chapter will specify some of international theories about sustainability which has become a key issue for the whole world because the concept of sustainability in sustainable development considers global and local issues such as climate changes, poverty, equity and unity of the world. The chapter generally will tackle development issues that relate to a triangle of sustainability and these issues are mainly attributed to:

- Environmental issues that derived from sustainable planning process to achieve integrated development that leads to built good environment. These derived issues will be assessed by environmental indicators to measure the quality of the sustainable development.
- Economic issues that integrated with the other issues to obtain a development of maximum benefit with less negative impact to environment and they assessed by economic indicators.
- Social issues derived from different planning process and integrated with other sustainable issues that caused optimization social benefits and these can be assessed by social indicators for sustainable development.

The chapter will specify the environmental indicators of 21 UN Local Agenda and types of general categorizations of land uses. The chapter will specify the elements in the visions of habitat sustainability referring to the four survey methods for urban river measurements. Also the chapter will specify the sustainability and the use of materials that related to:

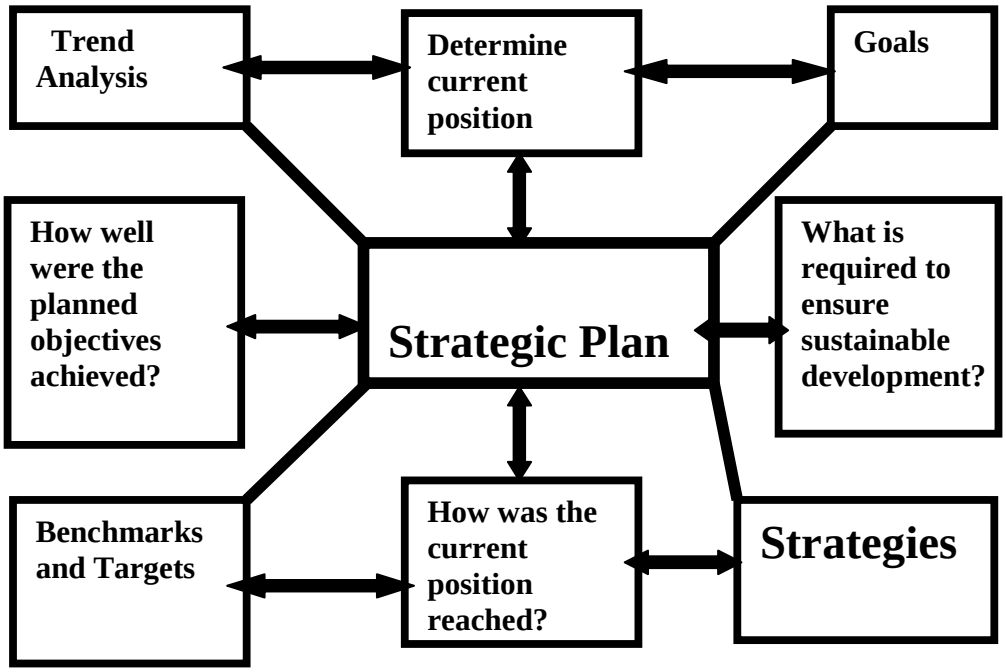
- Indices describing materials for river banks protection.
- Indices describing physical habitat features such as flow types and bank soils.
- Indices describing vegetation features.

Finally the chapter will specify methods of assessing sustainable development and that are Strategic Environmental Assessment SEA as a broad scale of assessment and Environmental Impact Assessment EIA as small scale of development assessment.

4:1 General Theories of Sustainability and Sustainable Development SD

The main goal of sustainable development, which is now becoming a key issue for the whole world, is to enable people through the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life for future generations. This broad goal is a result of empirical and theoretical scientific studies in the past twenty years which have seen a growing realization that the current model of development is unsustainable in a way that our consumption pattern having negative effect on the environment and climate. Therefore a promotion of clear understanding for sustainable development by governments and institutions to all people must be clarified in a way that we all have part to play, so as to contribute to the overall goal through our individual decisions. This decisive move toward more sustainable development, not because it is right thing to do, but also it is in our own long term best interests, which offer the best hope for the future. For achieving this main goal of sustainable development, there is a clear obligation on the more prosperous nations to support other poor nations in the transition towards a more equitable and sustainable world. The needs for sustainable development because of the reasoning attributable to the fact that the world's population is undergoing a continuing urbanization process and it is urban areas create many of the problems and requiring greatest resources to sustain them. The sustainable development concept required a scientific technique for the different planning issues and to assess performance that measuring negative and positive impacts of the development so as to gain better improvement for the general environment. The better environment obtaining from sustainable development will be gained from the main global and local issues tackled by it such as climate changes, poverty, equity, infrastructure, protection of natural resources, public health and improvement of life. These main issues can be tackled in the strategic planning for sustainability. The strategic planning in addition to the development of the strategies themselves, it should encompass use of benchmarking and target setting, analysis of trends and performance, and the setting of goals for achievement. These features are interlinked in the diagrammatic way shown in Fig 4-1.

Fig 4-1 Strategic Planning as part of a complete interlocking process



The sustainable development of the Nile Riverfront in Greater Khartoum will tackle the main two areas of this study method of stabilizing Nile River Banks and development of Nile Shores adjacent to them. The sustainable development of the Nile Riverfront can be possible and a key of this is to bring environmental, social, cultural, and economic influences together at the local scale where their impact can be observed and evaluated in order to enable the creation of a more cohesive urban and built environment that not only offers high development quality, but long term sustainability too. This can be gained by establishing guidelines and indicators for sustainable development of the Nile Riverfront in the study area based on considering a triangle of sustainability that attributed to environmental, economic and social issues as specified in below sections.

4:1:1 Environmental Issues

The environmental sustainability in general is an abstract concept although it does not mean to be measured with concrete indicators and there is no reason to suspect that the environmental is any different from other abstract concepts. Sustainable environment must addressed issues that required for successful sustainable development for built good environment. The environmental issues that must be addressed in a broad strategic way are attributed to infrastructure, water, energy, waste, river stabilization banks, materials, transport, greenway system and disposal system. An effective approach to these issues requires scientific planning at a level that can support integrated development within an urban context and framework. There are many useful examples and references for that effective approach for environmental issues such as those ten examples specified in Sustainability and Profit Book (2004). Those examples represents that issues attributed to environment for sustainable development could be possible as it occurring in some places. The key of it is to bring environmental, social, cultural and economic influences together at the local scale where their impact can be observed and evaluated in order to enable the creation of more cohesive urban elements and built urban environment that offers high design quality with long term sustainability.

The environmental issues and guidelines for sustainable development of the Nile Riverfront in Greater Khartoum should tackle:

- Methods of stabilizing Nile River Banks in the study area based on the building materials used and their impact on environment.
- Development elements on the Nile River Shores adjacent to those stabilized banks and these development elements should be familiar to the environment and sustain for long term.
- Infrastructure required for developing the study area and promotes environmental improvement.
- Transportation system with concentration on river traffic system because it is more economic and less pollutant to the study area such as Carbonate Dioxide.
- The utilization of the function of the Nile River as main blue that can support recreation and greenway system in the study area.

- Water, waste and disposal system in study area that able to contribute in improving the environment.
- Use of renewable energy in the sustainable development of the Nile Riverfront that familiar to the weather and maximizing environmental improvement and eliminating pollution in the study area.
- Materials types and flows within implementation process to be of those have positive impact on the environment.

These issues will be evaluated and assessed by environmental indicators that derive from planning process. The categorizations in most development are related to air emissions, quality of open space, water quality, greenhouse gas emissions, beach or river quality, urban waste and triple bottom line. Each category is composed of environmental indicators by which assessment to the environment due to the impact of the development can be obtained. The environmental indicators for assessing the development of the Nile Riverfront in Greater Khartoum will be derived from planning process and mainly attributed to:

- Methods of river stabilization banks.
- Traffic system.
- Application of greenway system in the study area based on potential main and sub attractive points in the study area.
- Accessibility to the Nile Riverfront in the study area to be admitted for all.
- The use of renewable energy that familiar to the environment.
- Skyline of the Nile Riverfront that reflect the urban sprawl of the riverfront in Greater Khartoum.
- Blue way of the Nile River and elimination of pollution in the study area.
- Quality of water, waste, disposal and infrastructure in the study area.
- Quality of the general environment due to the environmental impact assessment.

4:1:2 Economic Issues

Economic issues are related to the development of the resources without affecting global and local environment. These issues can be obtained from a modest degree of planning and scientific assessment for the economic drives changes. The development elements should be of less wasteful and of less polluting technologies but of optimum output that able to cause significant better economic changes in sustainable way. The economic issues and drives are mainly attributed to:

- Material where it should be of those familiar to the environment and of less wasteful and sustain for long time with minimum maintenance cost.
- Land the land should be developed to better changes to increase its value resultant from the development applied to it. This development should satisfy people needs and promoting sustainable economic output without affecting the environment or the future generation's requirements.
- Opportunities of jobs that required within different planning process implementation, management, monitoring and maintenance process.
- The transportation assessment due to the development, because time is money where the annual loss of money due to congestion in the United Kingdom as specified in (Sustainability and Profit Book, 2004) is over 20 billion Starling.
- The economic drive for changes lies in the consequences of climate change. These such as storms, flooding, drought that all have led to increase insurance claims that affect the economy.
- The consideration of Kyoto economic recommendations.
- The impact of environmental risks in the distribution of funds from national and local agencies towards less pollutant development to reduce capital investment costs.

The assessment of the economic issues resultant from the sustainable development of the Nile Riverfront in Greater Khartoum will be gained from the assessment methods related to the main economic indicators derived from different planning process.

4:1:3 Social Issues

Social is one of the basic line in the triangle of sustainability economic, social and environmental. Social issues in sustainable development normally tackled different elements that lead to improve societal characteristics in sustainable way. Social issues in sustainable development are integrated with economic and environmental issues. Social issues are used in sustainable development by social indicators and the main categorizations of them are:

- Demographic characteristics which play significant role in the different planning process for adequate sustainable development.
- Public services which should be reflected in sustainable development and could be assessed by social indicators derived from planning process.
- Social health should be received from sustainable development that leads to improve social health of the population. Social health can be gained from social health issues derived from sustainable development and lead to improve the environment and welfare of the people.
- Public utilities such as telecommunication system, electricity supply which should be of those types familiar to environment such as renewable energy and other public utilities derived from different planning process.
- Transportation methods in the sustainable development from the social, economical and environmental side that lead to perfect and improve the general social life of the population. Transportation issues include roadways, railways, airports and water transport.
- Education should be discussed in sustainable development objectives to satisfy various population needs for different education levels and age groups in hierarchical way starting from kindergarten, primary school, intermediate school, secondary school and universities.

These social issues will be assessed in sustainable development from social indicators that derived from planning process and mainly attributed to those social issues.

4:2 The 21 UN Local Agenda

Since the UN Conference on Environment and Development in 1992 and Habitat (ii) in 1996, sustainable development has been a concern for most countries of the world. The Environmental Sustainability Indicators ESI is fundamentally a policy tool designed to make environmental decision making more empirical and analytically rigorous. The environmental indicators have three basic functions simplification, quantification and communication that meet the following criteria:

(i) Scientifically sound.
(ii) Sensitive to the change in the parameters they are being intended to measure.
(iii) Show trends over time.
(iv) Measurable and capable of being updated regularly.
(v) The data and information are readily available.
(vi) Easily understood.

The indicators cover the environment, social issues and economic issues. The sustainable environmental indicators are increasingly being developed and applied as tools for decision makers and the general public for sustainable development. Development of environmental indicators is carried out internationally as well as in local and regional forums. The outcome of these researches is called Environmental Sustainability Indicators ESI or the 21 Agenda for (2005). The ESI as specified in the UN report for Environmental Sustainability Index Building Blocks- Indicators and Variables. Table 10 (2005) composed of five components, each component composed of four or five indicators where the total of these indicators for the whole five components are 21. Each indicator composed of certain variables where the total of these variables for the whole 21 indicators are 76 variables. These indicators can help to monitor progress towards sustainable development and identify where improvement need to be made by summarizing the characteristics of a particular system and describing the current state of economy, environment and society as specified in Table 4-1.

Table 4-1 ESI of UN which composed of components, indicators and variables source UN report Table 10 :(2005).

Table 10: 2005 Environmental Sustainability Index Building Blocks – Indicators and Variables

Comp-onent	Indicator Number	Indicator	Variable Number	Variable Code	Variable
Environmental Systems	1	Air Quality	1	NO2	Urban population weighted NO_2 concentration
			2	SO2	Urban population weighted SO_2 concentration
			3	TSP	Urban population weighted TSP concentration
			4	INDOOR	Indoor air pollution from solid fuel use
	2	Biodiversity	5	ECORISK	Percentage of country's territory in threatened ecoregions
			6	PRTBRD	Threatened bird species as percentage of known breeding bird species in each country
			7	PRTMAM	Threatened mammal species as percentage of known mammal species in each country
			8	PRTAMPH	Threatened amphibian species as percentage of known amphibian species in each country
			9	NBI	National Biodiversity Index
	3	Land	10	ANTH10	Percentage of total land area (including inland waters) having very low anthropogenic impact
			11	ANTH40	Percentage of total land area (including inland waters) having very high anthropogenic impact
	4	Water Quality	12	WQ_DO	Dissolved oxygen concentration
			13	WQ_EC	Electrical conductivity
			14	WQ_PH	Phosphorus concentration
			15	WQ_SS	Suspended solids
	5	Water Quantity	16	WATAVL	Freshwater availability per capita
			17	GRDAVL	Internal groundwater availability per capita
Reducing Environmental Stresses	6	Reducing Air Pollution	18	COALKM	Coal consumption per populated land area
			19	NOXKM	Anthropogenic NO_x emissions per populated land area
			20	SO2KM	Anthropogenic SO_2 emissions per populated land area
			21	VOCKM	Anthropogenic VOC emissions per populated land area
			22	CARSKM	Vehicles in use per populated land area
	7	Reducing Ecosystem Stress	23	FOREST	Annual average forest cover change rate from 1990 to 2000
			24	ACEXC	Acidification exceedance from anthropogenic sulfur deposition
	8	Reducing Population Pressure	25	GR2050	Percentage change in projected population 2004-2050
			26	TFR	Total Fertility Rate
	9	Reducing Waste & Consumption Pressures	27	EFPC	Ecological Footprint per capita
			28	RECYCLE	Waste recycling rates
			29	HAZWST	Generation of hazardous waste
	10	Reducing Water Stress	30	BODWAT	Industrial organic water pollutant (BOD) emissions per available freshwater
			31	FERTHA	Fertilizer consumption per hectare of arable land
			32	PESTHA	Pesticide consumption per hectare of arable land
			33	WATSTR	Percentage of country under severe water stress
	11	Natural Resource Management	34	OVRFSH	Productivity overfishing
			35	FORCERT	Percentage of total forest area that is certified for sustainable management
			36	WEFSUB	World Economic Forum Survey on subsidies
			37	IRRSAL	Salinized area due to irrigation as percentage of total arable land
			38	AGSUB	Agricultural subsidies

Comp-onent	Indicator Number	Indicator	Variable Number	Variable Code	Variable
Reducing Human Vulnerability	12	Environmental Health	39	DISINT	Death rate from intestinal infectious diseases
			40	DISRES	Child death rate from respiratory diseases
			41	U5MORT	Children under five mortality rate per 1,000 live births
	13	Basic Human Sustenance	42	UND_NO	Percentage of undernourished in total population
			43	WATSUP	Percentage of population with access to improved drinking water source
	14	Reducing Environment-Related Natural Disaster Vulnerability	44	DISCAS	Average number of deaths per million inhabitants from floods, tropical cyclones, and droughts
			45	DISEXP	Environmental Hazard Exposure Index
Social and Institutional Capacity	15	Environmental Governance	46	GASPR	Ratio of gasoline price to world average
			47	GRAFT	Corruption measure
			48	GOVEFF	Government effectiveness
			49	PRAREA	Percentage of total land area under protected status
			50	WEFGOV	World Economic Forum Survey on environmental governance
			51	LAW	Rule of law
			52	AGENDA21	Local Agenda 21 initiatives per million people
			53	CIVLIB	Civil and Political Liberties
			54	CSDMIS	Percentage of variables missing from the CGSDI "Rio to Joburg Dashboard"
			55	IUCN	IUCN member organizations per million population
			56	KNWLDG	Knowledge creation in environmental science, technology, and policy
			57	POLITY	Democracy measure
	16	Eco-Efficiency	58	ENEFF	Energy efficiency
			59	RENPC	Hydropower and renewable energy production as a percentage of total energy consumption
	17	Private Sector Responsiveness	60	DJSGI	Dow Jones Sustainability Group Index (DJSGI)
			61	ECOVAL	Average Innovest EcoValue rating of firms headquartered in a country
			62	ISO14	Number of ISO 14001 certified companies per billion dollars GDP (PPP)
			63	WEFPRI	World Economic Forum Survey on private sector environmental innovation
			64	RESCARE	Participation in the Responsible Care Program of the Chemical Manufacturer's Association
	18	Science and Technology	65	INNOV	Innovation Index
			66	DAI	Digital Access Index
			67	PECR	Female primary education completion rate
			68	ENROL	Gross tertiary enrollment rate
			69	RESEARCH	Number of researchers per million inhabitants
Global Stewardship	19	Participation in International Collaborative Efforts	70	EIONUM	Number of memberships in environmental intergovernmental organizations
			71	FUNDING	Contribution to international and bilateral funding of environmental projects and development aid
			72	PARTICIP	Participation in international environmental agreements
	20	Greenhouse Gas Emissions	73	CO2GDP	Carbon emissions per million US dollars GDP
			74	CO2PC	Carbon emissions per capita
	21	Reducing Transboundary Environmental Pressures	75	SO2EXP	SO_2 Exports
			76	POLEXP	Import of polluting goods and raw materials as percentage of total imports of goods and services

Table 4-1 illustrates the great care of the UN for improving the environment in the world by establishing objective measurements to environmental indicators.

4:3 Land uses

The survey of land uses must reflect the heterogeneity of the main six broad categories (Urban, Agricultural, Range land, Forest land, Wet land and Barren land). These six broad categories in level one can be subdivided into 21 land uses types as illustrates in Table 4-2.

Table 4-2 land Uses Categories and Types source (Khartoum CBD Study Team, 1999, p.30)

Land Use in Level 1	Land Use Codes in Level 2	Description
UR (Urban)	Re	Residential
	Cm	Commercial
	In	Industrial
	Ic	Industrial/commercial
	Tr	Transport
	Sw	Sewage Treatment Works
	Ld	Landfill/Refuse Deposits
	Dr	Derelict Land
	Cn	Contaminated Land
AG (Agriculture)	Cr	Cropland
	Pa	Pasture
	Or	Orchard
	Fe	Close Feeding (Battery Farms etc)
FO (Forested)	Co	Coniferous
	Dd	Deciduous
	Ow	Open Woodland
PA (Pasture)	He	Heath land
	Sc	Scrub
	Op	Open park land (community grass etc)
	Rc	Recreational land (Playing fields)
	Ce	Cemeteries / Crematoria
	Es	Estate Lands (Inc. MOD)
OW (Open Water)	La	Lake
	Rv	Reservoir
	Ca	Canal
	Rq	Reclaimed Quarry

Land Use in Level 1	Land Use Codes in Level 2	Description
	Tb	Tributary
WE (Wetland)	Fo	Forested
	Nf	Non- Forested
BA (Bare)	Sm	Strip mines/ Open Cast
	Ex	Exposed Rock
	Tn	Transitional

Table 4:2 illustrates the categorizations of land uses but our study will concentrate on the first category that focuses on urban land uses. The study will tackle the impact of the sustainable development on those land uses and magnitude and degree to better changes.

4:4 Elements of River Habitat Sustainability

The important issues that can be obtained from visions of habitat for sustainable development at urban river are as summarized below:

- Collection of suitable data that leading to suitable sustainable development
- Establishing of suitable methods that are applied to River Habitat Survey RHS and Urban River Survey URS techniques.
- Standardization elements based on cumulative and quantitative RHS techniques.
- Establishing suitable assessment methods to measure the impacts of the different elements of the development on the environment.
- Involving local people in the survey work and RHS applied to any study area.
- Raising the awareness of the people about SD.
- Studying carefully all existing elements in any study area and their magnitude and potentiality in the SD.
- Furnishing and stipulating suitable implementation and monitoring methods.

These issues as Visions of Habitat for SD at Urban Rivers can be obtained through River Habitat Survey RHS applied to urban rivers and urban sustainable development as environmental technique used to assess the physical character of the river and denoted in the survey measurements as specified in below sections.

4:4:1 Background Measurements

Background Measurements of RHS contains a lot of data such as the date, time of the survey, grid reference and general conditions for the assessment. Properties that relate the stretch to its catchments, provide a context for the survey and can be derived mainly from secondary sources (e.g. altitude, geology, distance from source, slope) or a brief assessment in the field (e.g. valley form) are also recorded.

4:4:2 Spot-Check Measurements

Spot- Check Measurements survey composed from a number of spots recorded within one meter wide transects across the channel located every 50 m along the stretch (10 spot checks per 500 m stretch). The attributes associated with each spot-check are assessed by eye from either the bank or the channel. This includes the physical attributes of the channel in channel macrophysics, the bank vegetation in terms of its complexity and immediate land use (5m from the bank top).

4:4:3 Once-Only Measurements

They are assessed once within the stretch. They include bank and channel width, water depth, bank top and bank full height, and embank height.

4:4:4 Cumulative Measurements

Cumulative Measurements comprise all the measurements contained within the RHS. Continuous assessment is made along the 500 m stretch and a single recording made at the end of the survey. These attributes include the presence of trees and their associated features, bank profile types, land use, channel features, artificial features, special features and management

attributes. The Cumulative Measurements compose of 12 separate categories comprise the different measurements.

4:5 Sustainability and the Use of Materials

The Aggregate Indices describes environmental indicators that derived from Urban River Survey URS data, and these indices can be developed by using URS data in a way that, indices will be mainly attributed to one of the following three groups Materials, Physical Habitats or Vegetation Features as specified in Sustainable Management for Urban River's Floodplains SMURF (2003).

4:5:1 Indices Describing Materials

These indices are separated into two components indices describing natural or mobile materials such as (silt, sand, gravel etc) and artificial or immobile materials such as (concrete, bricks, bedrock etc). The URS records the natural and artificial materials in each spot check measurements at the 10 cross sections which recorded along the 500 m stretch according to categories compatible with the Wentworth particle size scale. These spot check measurements are converted by the SEDCAL index into an approximate average, particle size for the stretch in phi units as specified below:

$$\text{SEDCAL} = \frac{(-8*BO) + (-7*CO) + (-3.5*GP) + (-1.5*SA) + (1.5*SI) + (9*CL)}{(BO + CO + GP + SA + SI + CL)}$$

Where (BO= Boulder, CO=Cobble, GP= Gravel-pebble, SA= Sand, SI= Silt, CL=Clay)

The proportion of the stretch index with bed reinforcement is:

$$\text{Proportion Immobile Substrate} = \frac{\text{number of spot-checks with immobile materials x10}}{\text{Number of spot-checks}}$$

These principles or rules can be applied to bank materials and bank protection as specified in next section.

4:5:1:1 Bank Materials

In URS the data of the two river banks are gathered separately although they could be combined together to give stretch summary. The URS records similar measurements for mobile bank materials as for the channel substrate based upon the Wentworth scale. The BANKAL index converts these spot-check measurements into an approximate average particle size for the stretch banks in phi units as specified below:

$$BANKAL = \frac{(-9*BO) + (-8*CO) + (-2.5*GS) + (4*EA) + (9*CL)}{(BO + CO + GS + EA + CL)}$$

EA= Earth

The proportion of immobile Bank Materials (concrete, concrete and bricks, laid-stone, sheet piling, and bed rock) is calculated in the same way as for immobile substrate.

4:5:1:2 Bank Protections

The different protection types that used in urban channels can be placed into various categories according to their attributes and then their numerical value relating to their durability and permeability can be ascribed as specified in Table 4-3.

Table 4-3 Bank Protection Types source (SMURF model, 2003, p.22)

Category	Bank Protection Types	Numerical Value
None	None , Washed Out	0
Biodegradable	Reeds, Wood Pilling, Willow Spilling	1
Open Matrix	Rip Rap, Gabions, Builders Waste	2
Solid	Concrete, Concrete and Brick, Brick/ Laid Stone, Sheet Pilling	3

The level of protection for each bank can be calculated from the numerical value given to each category as specified in the below formulae:

$$\text{BANK PROT} = \frac{(O^* \text{NONE}) + (1^*\text{BIO}) + (2^*\text{OMP}) + (3^*\text{SOL}) \times 3}{(\text{NONE} + \text{BIO} + \text{OMP} + \text{SOL})}$$

Where: (NONE = No bank protection, BIO = Biodegradable protection, OMP = Open matrix protection, and SOL = Slid protection)

The overall type and level of protection for the stretch can be taken from the URS cumulative measurements. The types of protection to the river bank are grouped into the above four categories, so as to calculate the proportion of the stretch and then the

NONE, BIO, OMP, SOL protection can be estimated.

4:5:2 Indices Describing Physical Habitat Features

The indices describing physical habitat composed from the indices describing flow types, habitat features and bank profile as summarized below:

4:5:2:1 Flow Types

The most important indicator of flow hydraulic and channel bed morphology is the water surface patterns. The diversity of the hydraulic and morphology is characterized by the following two indices:

(i) The dominant flow type gives an indication of the general character of the stretch and this can be determined by selecting the flow type that recorded in the most times in the Spot Check Measurements. Partially the flow types reflect the flow velocity, and so the dominant flow type can be arranged along a flow velocity gradient from faster flow types to slower flow types.

(ii) The number of flow types within a stretch is important for looking at bed form variability and hydraulic and by accounting the number of different flow types that recorded in the Spot- Check Measurements, the hydraulic and bed form variability can be ascertained. The indices give an indication of the heterogeneity of the stretch in terms of its, hydraulics and associated channel morphology.

4:5:2:2 Habitat Features

The number of different habitat types observed within the stretch which can be drawn from the URS data provides a simple integrative index of the diversity of habitats that are present. This integrative index represents a count of in-channel habitat types, including both the morphological and present hydraulic habitats.

4:5:2:3 Bank Profiles

There are two different categories of bank profile that can be recognized in the URS which are "artificial and natural" reflecting the historical management practices and the level of bank profile recovery from past modification. The number of natural and artificial profiles comprises two of the indices from this group of measurements, which can be an ascertained from the Cumulative Measurements. This gives an impression of heterogeneity of the channel in terms of its bank characteristics, and provides an indication of the processes involved in the recovery of the channel.

4:5:3 Indices Describing Vegetation Features

The indices describing vegetation features composed from the indices describing bank face and top features, channel vegetation and pollutions measurements as specified below:

4:5:3:1 Bank Face and Top Structure

The URS records the vegetation structure in the same way as the RHS. Simple index of the bank vegetation can be combined in the spot check measurements, where higher value represents increased vegetation complexity and vice versa. The channel may display different complexities of vegetation between the banks, top and face of the bank. Therefore a calculation is made for each bank top and face structure using the following calculation:

$$\text{BANKVEG} = \frac{(0*B) + (1*U) + (2*S) + (3*C)}{(B + U + S + C)} \times 3$$

Where (B= bare, U= uniform, S= simple and C= complex)

The presence of trees is calculated on the scale of absent to entire length of the stretch river banks, and the right and left bank can be added together to give a representative index of cover or total tree cover for the whole stretch (none = 0, isolated/scattered = 1, regular scale = 2, occasional lumps = 3, semi continuous = 4, continuous = 5)

Tree features (shading of channel, overhanging boughs, exposed bank side roots, under water tree roots, fallen trees, and coarse woody debris) represent the degree to which marginal trees directly influence the river channel environment. They are measured by APE scale (where the score of absent = 0, present = 1, extensive = 2), and the score of each of the above six tree features are added together to give an index of tree influence along the stretch called the total tree feature score. Combining these two scores represents the extent and level of impact of the different tree associated features.

4:5:3:2 Channel Vegetation

The measurement taken in the spot checks can be separated into three important components to assess the nature of the Macrophytes within the channel which can help to indicated water quality. The number of vegetation types consists of a simple count of the number of different Macrophyte groups over the stretch, and these types could be as high as ten in stretches that possess high species numbers, which give a picture of the dominant channel vegetation type. For future use analysis the vegetation types must be ranked according to the properties they possess or their effect on urban channels. The attenuation flow in the channel will be affected lesser or greater by the Macrophyte types which can be arranged on linear scale from low to high according to their potential effect on the hydraulic regime of the stretch as illustrates in Table 4-4

Table 4-4 low and high attenuation of flow in urban channel source (SMURF model, 2003, p.25)

Low attenuation of flow	0 = None	None
↓	1= LML	Liverworts/ Mosses/ Lichens
↓	2=FFL	Free Floating
↓	3= AMP	Amphibious
↓	4= EBH	Emergent Broadleaved Herbs
↓	5= FAL	Filamentous Algae
↓	6= RFL	Floating Level (rooted)
↓	7= SLL	Submerged Linear Leaved
↓	8 = SBL	Submerged Broadleaved
	9 = SFL	Submerged Fine leaved
High Attenuation of flow	10 = RSR	Emergent Reeds/ Sedges/ Noshes

4:5:3:3 Pollution Measurements

The pollution measurements can be divided into three different indices (good, average and bad). The total pollution scores can be calculated from the first five variables (water odours, sediment odours, oils, surface scum and gross pollution) that are listed in above Table 4-4 which can be measured by APE scale. The clarity which can be assigned a similar score where good, average and poor score that equal to 0,1 and 2 respectively are used where the higher the score, the higher the extent of pollution within the stretch. The number of leach points and the number of input pipes comprise the other two indices for pollution. The total number of each that is measured in the URS can be converted to scores.

4:6 Methods of Assessing Urban Development

There are mainly two types of assessment measuring the impact of a project on the environment. The first method is assessing the impact of development on environment and the second method is describing the general framework and strategy as specified in below sections.

4:6:1 Environmental Impact Assessments EIA

Generally the term "Environmental Impact Assessment EIA describes a procedure that must be followed for certain types of project before they can be given approval for development. Normally it contains analysis of quantitative and qualitative statements of data obtained by the assessment processes detailed in the EIA.

The EIA for the Nile River Front will contain a full description for the following information:

- The physical characteristics of the whole development of the Nile River Front.
- Land use requirements during the construction and operational phase of the development.
- Main characteristics of the production processes, estimate by type and quantity of the residues and emissions like water, air, soil pollution, noise, vibration, light, heat, radiation.
- Population, water, climatic factors, architectural and archaeological heritage, air, landscape, material assets and the interrelationship between these and the other factors.
- Significant effects of the development of the Nile River Front on the environment whether these effects are direct, indirect, short, medium, long or permanent.
- Technical deficiencies or lack of information for the development and any alternatives studied that more considering the environmental effects.

This information can constitute part one of the EIA, and part two can include the following information:

- A description of the development comprising information on the site, design and size of the development of the Nile River Front.
- Data required identifying and assessing the main effects that the development of the Nile River Front is likely to have on the environment.

- Description of measures envisaged so as to reduce or avoid significant adverse effects.
- Outline the main alternatives studied and their impact on environment.
- A technical summary of information that is required for the suitable sustainable development of the Nile River Front.

4:6:2 Strategic Environmental Assessments SEA

The Strategic Environmental Assessment SEA is a document produced by a public body and required by legislation, a regulation or administrative order when a plan or a program is being proposed. There are some SEA plans obligatory, like regional spatial strategies, regional transport strategies, regional economic strategies, local transport plans, local development frameworks, while others are not. The SEA report normally includes the following information:

- The main objectives of the plan or program.
- A description of the state of the environment.
- The environmental protection objectives whether, national or international, that are relevant to the plan or program and how they have been taken into account.
- The significant effects on the environment including on water, population, human health, biodiversity, soil, climate, landscape, heritage.
- Alternatives if required.
- Monitoring of measurement elements of how the plan or program affects the environment in practice.

The main stages of the SEA process are as specified below:

- A decision of as to whether a SEA plan is required
- Identification of the existing environmental conditions and trends (base line information)
- Identification of the main issues

- Development of alternatives
- Evaluation of existing situation to predict possible environmental impact.
- Evaluation of the environmental impact.
- Preparation of SEA
- Consultation of public and authorities.
- Decision
- Monitoring.

4:7 Summary of Chapter Four

The chapter specified general theories about sustainable development and the developed methods that measured sustainability as one of the basic globalization issues. The chapter tackled the triangle of sustainability related to environmental, economic and social issues. These issues will be useful to our study and addressed the sustainable development to the Nile Riverfront in Greater Khartoum and formulation of them in the different planning process to obtain adequate framework for developing the study area.

The chapter also tackled the following international theories that related to sustainability and these such as:

- The 21 Local Agenda since sustainability became a key issue for all countries whom share this earth and under one sky.
- Types of land use that affected positively or negatively by any development.
- Elements of river habitat sustainability as denoted in background, spot-check, once-only and cumulative survey measurements.
- Sustainability and the use of materials and this obtained from the indices that describing materials used for river banks protection, physical habitat features and vegetations.
- Methods applied for assessing sustainable development and normally the two main methods as specified in this chapter are Strategic Environmental Assessment SEA and Environmental Impact Assessment.

This theoretical chapter concentrated mainly on the theory of sustainability and as it clear it is integrated approach based on the triangle of sustainability economic, social and environmental. For the sustainable development of the Nile Riverfront in Greater Khartoum consideration of these issues will be taken in the different planning process.

CHAPTER FIVE:

CAIRO, EGYPT AS SIMILAR CASE STUDY

AND OTER CASES

5:0 Introduction

Chapter Five will collect data from Cairo, Egypt as a main similar case study incorporated with data collected from other cases studies in the world. The selection of Cairo as main similar case study is due to the similarities between Cairo and Khartoum. The aim of this chapter is to study how the Nile River flows was managed and how the Nile River Shores were developed in Greater Cairo. The collected data from Greater Cairo after specifying the justifications of selecting it as similar case study will tackle the following issues:

- Historical background about Cairo that reflected flood problems before managing and stabilizing the Nile River Banks in Greater Cairo.
- The development programmes applied to Nile River Front at Greater Cairo that indicated the role of governmental and private sectors in developing Cairo Nile River Shores.
- The divisions of the Nile River Shores into manageable sectors as specified in the study carried by the University of Cairo for the development of the Nile River Front at Greater Cairo in (2005).
- The Greenway system for Greater Cairo as specified in the previous study and how it can be applied to Greater Khartoum with a concentration on the Nile River as main Blue Way System.
- The development of potential areas in Greater Cairo such as the development of Asr-Alnabi, Sialat Al-Rwada and Rwdat Al-Farag as specified in the study of the University of Cairo in (2005).
- The general observations of the author illustrates with photos taken by the author that represent the current situation of the Nile River Front in Greater Cairo.

These issues incorporated with those information collected in previous chapters will be used as guidelines for a development of the Nile River Shores in Greater Khartoum.

5:1 Selection of Cairo as similar case study

The similar case study is carefully selected which will be the treatment of the Nile River Front at Greater Cairo, Egypt. The selection of Greater Cairo as similar case study is selected for many reasons and justifications as specified below:

- Both cities Cairo and Khartoum are located along the Nile River as illustrated in Fig 5-1.
- Both cities Cairo and Khartoum are composed of urban areas that depend on the functions of the Nile River for the sustainability and capability of those urban elements.
- The Role of the Nile River in the civilizations of both Egypt and Sudan that strengthens the relationship between the populations of the two countries.
- The similar nature of the Nile River pattern system.
- The similar and interrelation culture of people in Egypt and Sudan.
- The similar environment of Cairo and Khartoum.
- The similar economic status of Egypt and Sudan.
- The similar population density of the two Cities (Cairo about 10 millions & Khartoum about 6 millions).
- Both cities Cairo and Khartoum utilized the Nile River as main blue way system in improving the urban environment and decreasing pollutions, by constructing urban environmental schemes without affecting the main stream of the Nile River.

The data derived from case study will be a key issue for the exploration method that will be applied to the study and method of collection primary data. The methodology of data collection derived from case study will explore different elements of planning process and present this information in a conceptual scientific way.

Fig 5-1 Location of Cairo (source www.egyptian maps)

5:2 Historical Backgrounds about Cairo

The earliest ancient settlements of Egyptian urban civilization were destroyed by the annual flooding of the Nile and these ancient cities such as Mephis, Thebes and Tel-el Amarna that remarkable by their stones monuments, tombs and temples. The ancient Egyptian cities composed of holly self-contained city for dead people built of stone on high land away from the risk of the annual flooding of the Nile. These holly cities composed of simple geometrical large scale shapes such as pyramids, prisms, temples, obelisks etc to cater for long survival after death as illustrates in Fig 5-2.

Fig 5-2 Holy City source Egyptian civilization old historical Cairo, Benevolo (1980)

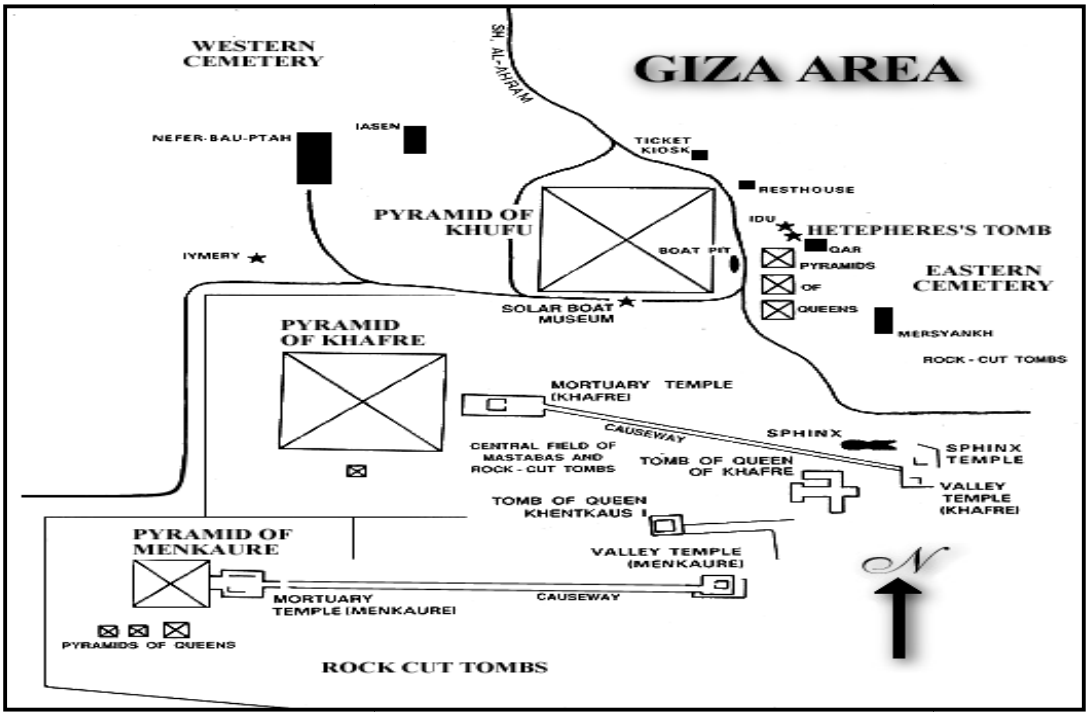


Fig 5-2 illustrates the pyramids zone in the holly city at Giza Area that located far from the flood zone near the Nile River Banks.

The city growth of Cairo within the different periods is summarized in the below sections:

5:2:1 Old Cairo before Islam

Cairo is located on the edge of the Nile River, near the spot where the river splits into two branches at the delta. Old Cairo represented the archaeological periods that extended from the 1st dynasty to the 31 dynasty periods, Roman and Byzantine periods. Great numbers of magnificent carved masonry and domes have been preserved in Cairo, principally in the old medieval areas as specified in Fig 5-3

Fig 5-3 Old Cairo source Egyptian civilization old historical Cairo, Benevolo (1980)

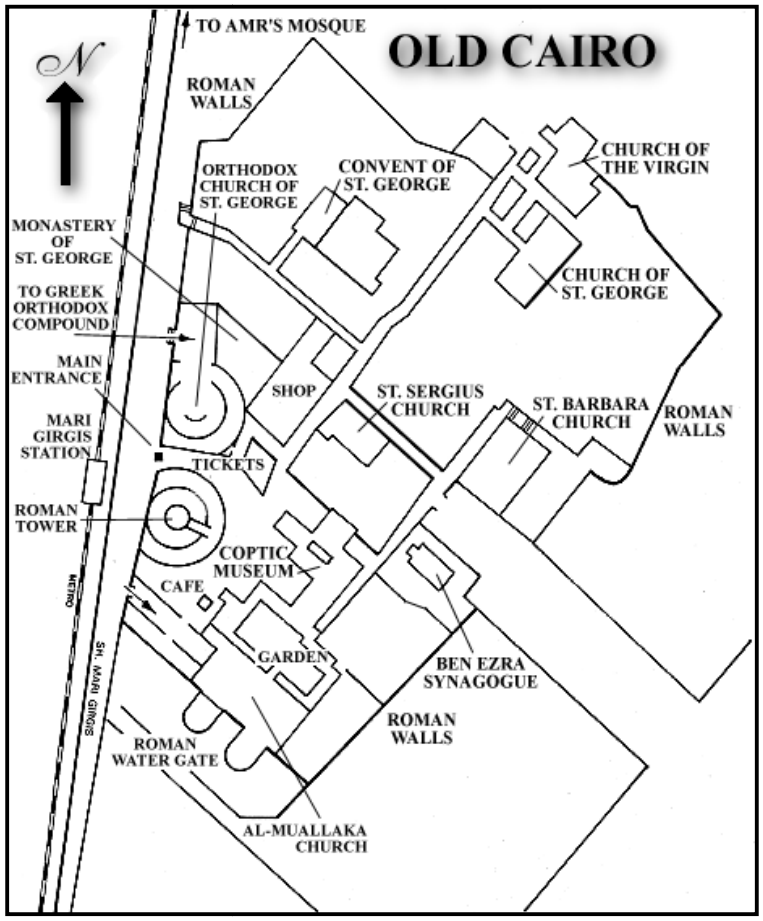


Fig 5-3 illustrates the presentation of the cultural heritage for the different archaeological periods in Old Cairo.

5:2:2 Cairo after Islam

Arab forces under Amr Ibn Alas reached the vicinity of contemporary Cairo in 640 AD, where he established a small military town called Fustat. Old Cairo was known as Al- Fustat and was founded in 648 AD near other Egyptian cities and villages including the old Egyptian capitals such as: Memphis, Heliopolis, Geeza, and Byzantine fortress of Babylon. Fustat was built as a military garrison for Arab troops due to its central location, then it became a regional centre of Islam during the Umayyad period. Cairo today was officially established during the Fatimid period in AD 969 as an imperial capital and it absorbed Fustat and the other historical towns that became part of Greater Cairo.

`` *In the year AD 969 the lines of a small rectangular military capital were staked out by a Fatimid conquering army from North Africa. Set near an existing town founded more than three centuries earlier by another military conqueror imbued with similar religious favor…..``(Abu Loughod* ,1971*)*

During its history various dynasties would add suburbs to the city and construct important structures that became known throughout the Islamic world including AlL Asher Mosque. Conquered by Saladin and ruled by Ayyubids starting in 1171, it remained an important centre of the Muslim world. Slave soldiers or Mamluks seized Egypt and ruled from their capital at Cairo from 1250 to 1517 when they were defeated by the Ottomans. Following Napoleon's brief occupation, an Ottoman officer named Mohammed Ali made Cairo the capital of an independent empire that lasted from 1801 to 1882. The city came under British control until Egypt attained independence in 1922.

Today, Greater Cairo encompasses various historic towns and modern districts into one of the most populous cities in the world. Cairo is the capital of Egypt, and indeed its history is intertwined with that of the country and its different historical boundaries illustrates in Fig 5-4.

Fig 5-4 Historical Cairo source Abu Loughod (1971 page 85)

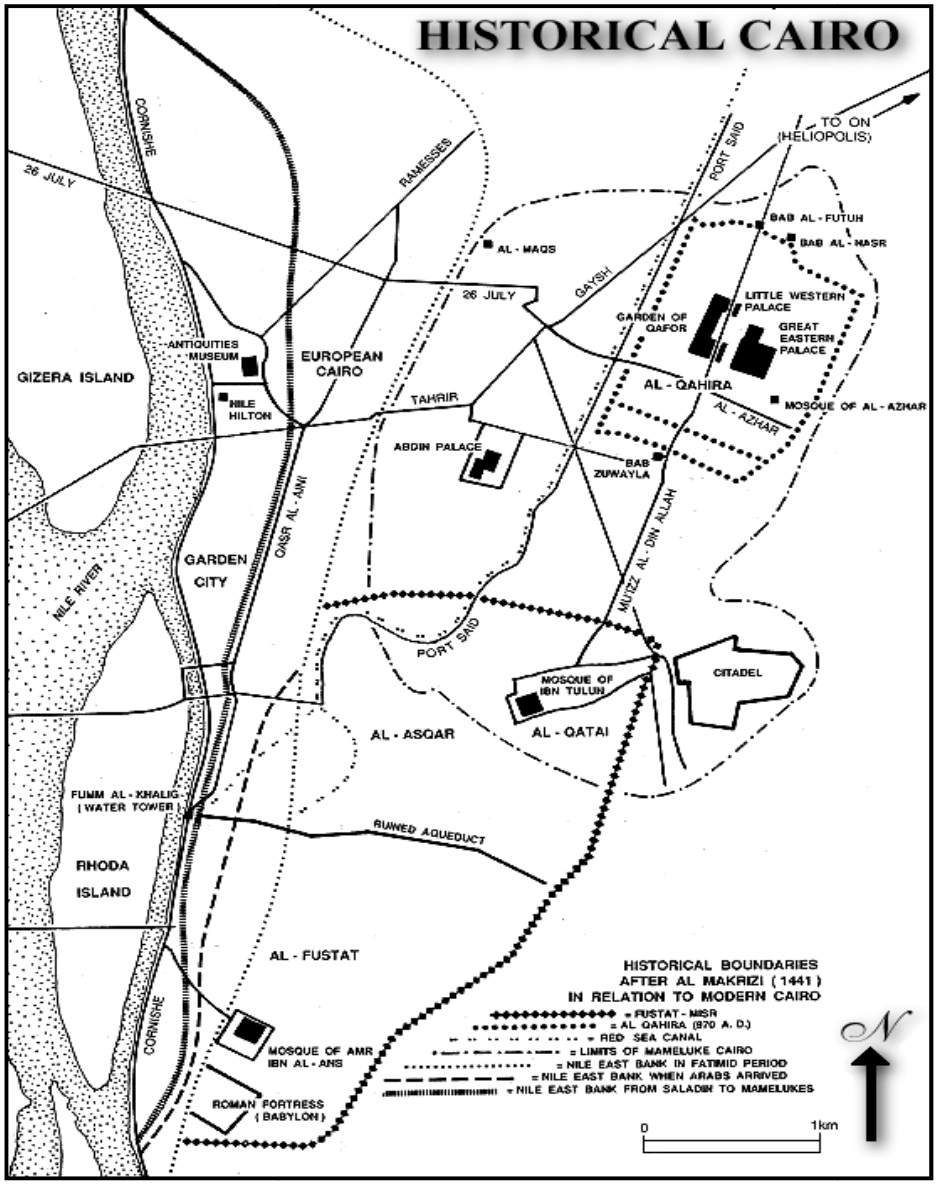


Fig 5-4 illustrates the archaeological historical zones for the different historical periods after Islam and the large flooded area.

5:2:3 Modern Cairo Transformations

Modern Cairo Transformations will tackle the Cairo transformation within the 19th and the 20 th centuries as specified in below section.

5:2:3:1 Cairo Transformations within the 19th century

Cairo transformations within this century composed of three stages by French Troops, Mohamed Ali and Khedive Ismail as specified below:

- The first stage of transformation in this century was the development applied to Cairo by French troops. The French divided Cairo to eight large sections known as a thumn (Arabic for one/ eight). These eight sections composed of 53 harats. The impact of French occupation for their military reasons was the re-planning and reorganization of the population settlements, widening and opening new roads as specified by, Hsham Khairy, Cairo Political Transformation (2000).

- The second stage of transformation was done by Mohamed Ali who ruled Egypt after evacuation of the French troops. He replaced all the older gates that led to the various streets and quarters by main entrances guarded by private watchmen. He built his palace in Shubra near the bank of the Nile and established Pasha's arsenal and docks. Also he was encouraged the elite to build palaces on the intervening land between Bulaq and Shubra. Bulaq became the site of new industrial establishments such as The National Press, river boats arsenal, spinning mills and textile factories as specified by, Ayman Hassan, Site Planning of Cairo Water Front (1996).

- The third stage of transformation was executed by Khedive Ismail. He developed Cairo into a modern European city with the new plan proposed in 1869 AD. The plan of modern Cairo was introduced by Haussmann in Paris which was characterized by the creation of wide boulevards to facilitate vehicular movement and divided the city into different segments one for the elite and visitors and the other for indigenous population. The plan was rectilinear grid and radial plans, free standing structures and wide streets to communicate vehicular traffic as illustrated in Fig 5-5

Fig 5-5 Cairo Plan in 1869 (source Wafa Monem, Evolution Dynamics of Cairo, PhD Thesis 'March 1990, page 105' University of Cairo)

Fig 5-5 illustrates that the development plan was composed of different zones where each zone was planned for specific purpose and these zones communicated with wide roads.

5:2:3:2 Cairo Transformations within the 20th century

Cairo transformations in this century can be divided to the following phases:

- Phase one which extended up to 1927 where Cairo population increased from 589,572 in 1887 to 678,423 in 1907 and 1,100,000 in 1927. This increased of population was a resultant of rapid urbanization, immigrations of foreigners that occurred due to commercial promise and population increased. In spite of that population increased, the area remained constant as in 1869 master plan 161.7 km^2. But the city was growing rapidly due to the influence of the European interrelationship, political and economic situations as specified by, Hsham Khairy, Political Transformation (2000).

- Phase two was extended from 1927 up to 1947. The population of Cairo increased in this period from 1,100,000 in 1927 to 2,000,000 in 1947 with annual growth rate of 5% and 1.8 % mortality rate. The area of the city increased from 161.7 km^2 in 1927 to 178 km^2 in 1947 as specified in above source.

- Phase three tackled the development plan for Greater Cairo in 1983. The population of Greater Cairo increased from 2 million in 1947 to 8 millions in 1980 as specified in above source. The development of the Nile Riverfront in the development plan of Greater Cairo in 1983 aims to change the function of the cornice from traffic use to mix used. The development plan aimed to create mix used activities such as recreational, tourism, cultural, commercial and sports along the Nile River front. The general concept and strategy of the plan for the development of the Nile Riverfront concentrate on the development of the cornice and remove contaminated activities that caused pollution to the Nile River in Greater Cairo. The development plan tackled three basic areas area one composed from the cornice adjacent to the CBD area, area two composed from agriculture area at the south of Aljiza and area three composed of residential area along the Nile Riverfront as illustrates in Fig 5-6.

Fig 5-6 Greater Cairo development plan 1983 (source the Study for Development of the Nile River Front at Greater Cairo 'March 2005, second book page 12' by University of Cairo)

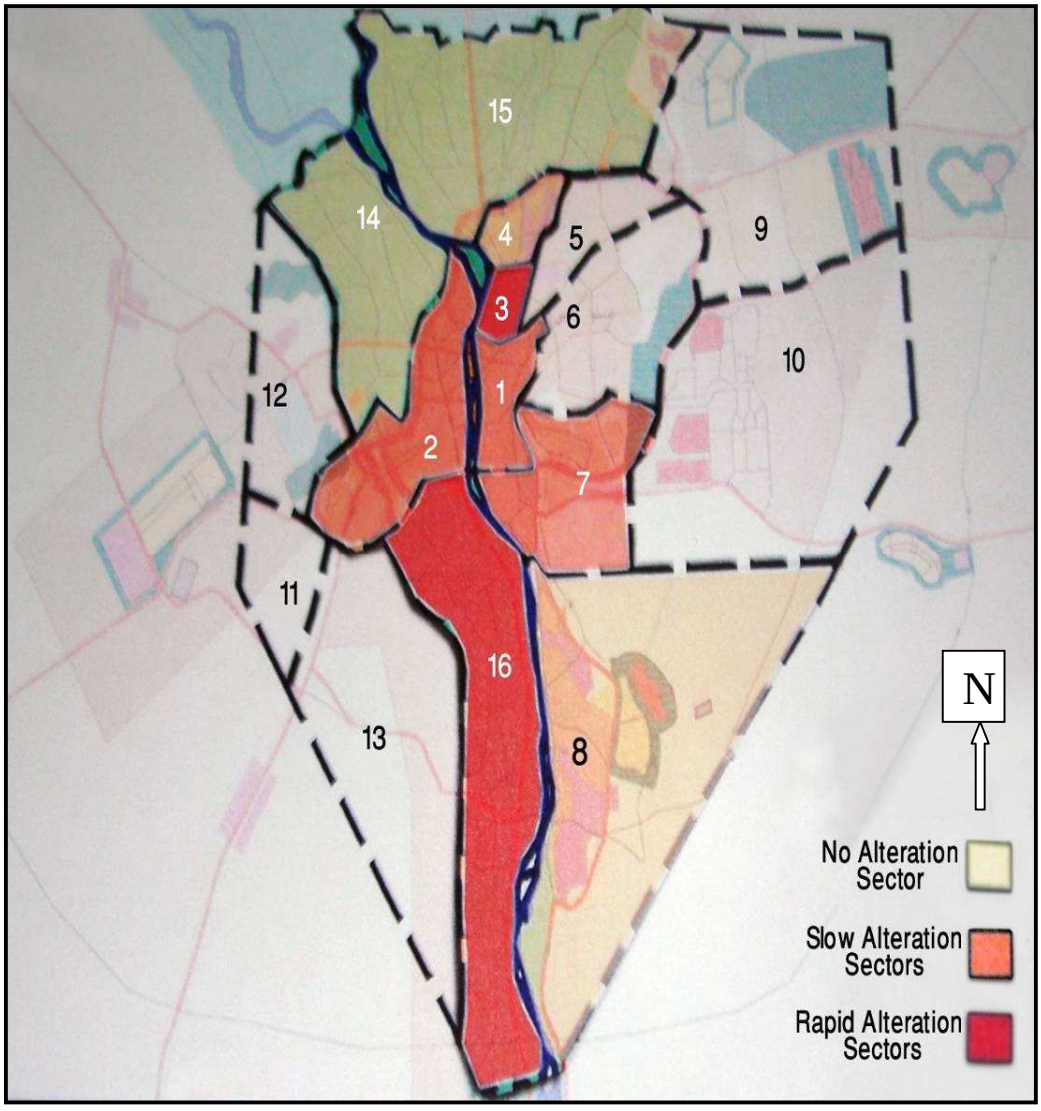


Fig 5-6 illustrates the areas on the Nile Riverfront is of continuous rapid alterations particularly those areas near the CBD area in Greater Cairo.

- Phase four tackled the development of the Nile Riverfront in the development plan of Greater Cairo in 1991. The development plan aimed to improve the environment of Greater Cairo by developing the Nile Cornice, creating greenway system, directing future development towards desert instead of concentration along the Nile Riverfront, removing of polluted activities away from the Nile River, protecting agricultural and conservation areas on the Nile Riverfront and stipulating legislations that required for directing the development along the Nile Riverfront in Greater Cairo as illustrates in Fig 5-7.

Fig 5-7 Cairo development plan in 1991 (source the Study for Development of the Nile River Front at Greater Cairo 'March 2005, second book page 17' by University of Cairo)

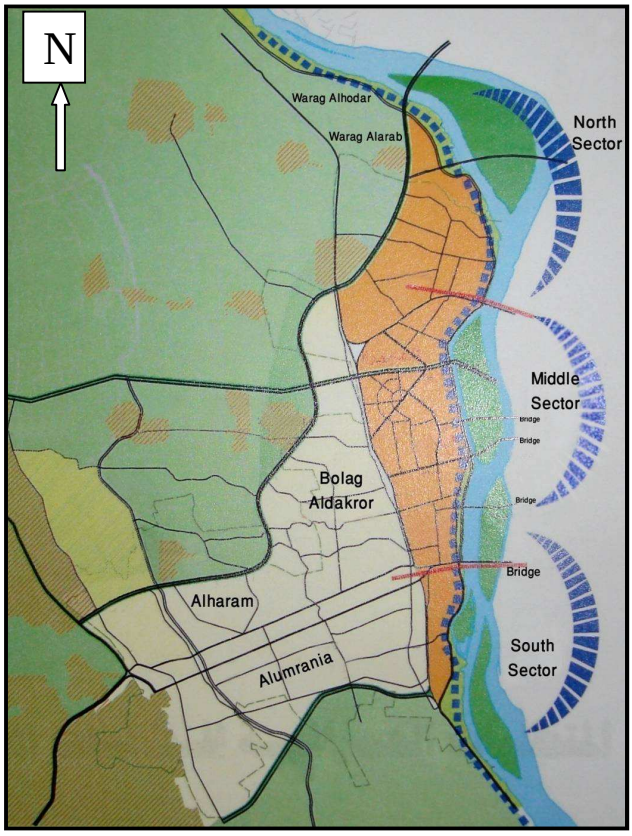


Fig 5-7 illustrates the development of Cornice along both sides of the Nile Riverfront in Greater Cairo.

5:3 Divisions of the Nile River Shores in Greater Cairo

The Nile River Shores and the areas adjacent to them that were known with the Nile Riverfronts were divided into 61 manageable shores as specified in the study carried by, the Research Consultancy and Planning Centre RCPC in the University of Cairo (2005). The study defined the Shore as that area extended between water line of the main stream and main road along the river such as (Cornice Street) or that area located between the main stream and riverfront. River Shore depends on the width of the shore area as a resultant of the hydrology and morphology of Nile River. Shore area represents the most sensitive area that requires special legislations and considerable planning schemes. The riverfront is composed of that area extending along the river that is connected visually with the river and is seen easily from the main stream or river shores without obstacles. The Nile River in Greater Cairo contained different activities such as floating activities for tourists, local activities, cultural activities, recreational activities and service activities.

The 61 manageable Shores and their Riverfronts were divided to:

- 25 Shores on the East side of the Nile River.
- 22 Shores on the West side of the Nile River
- 14 Shores around the river islands (Al-Zamalik, Al-Roda, Al-Dahab and Al-Warag).

The total length of these shores is 45 kilometres extending on the East and West sides of the Nile River in Greater Cairo as illustrates in Fig 5-8 & 5-9.

Fig 5-8 Nile River Shores in Greater Cairo (source the Study for the Development of the Nile River Front at Greater Cairo 'March 2005, first book page 27' by University of Cairo)

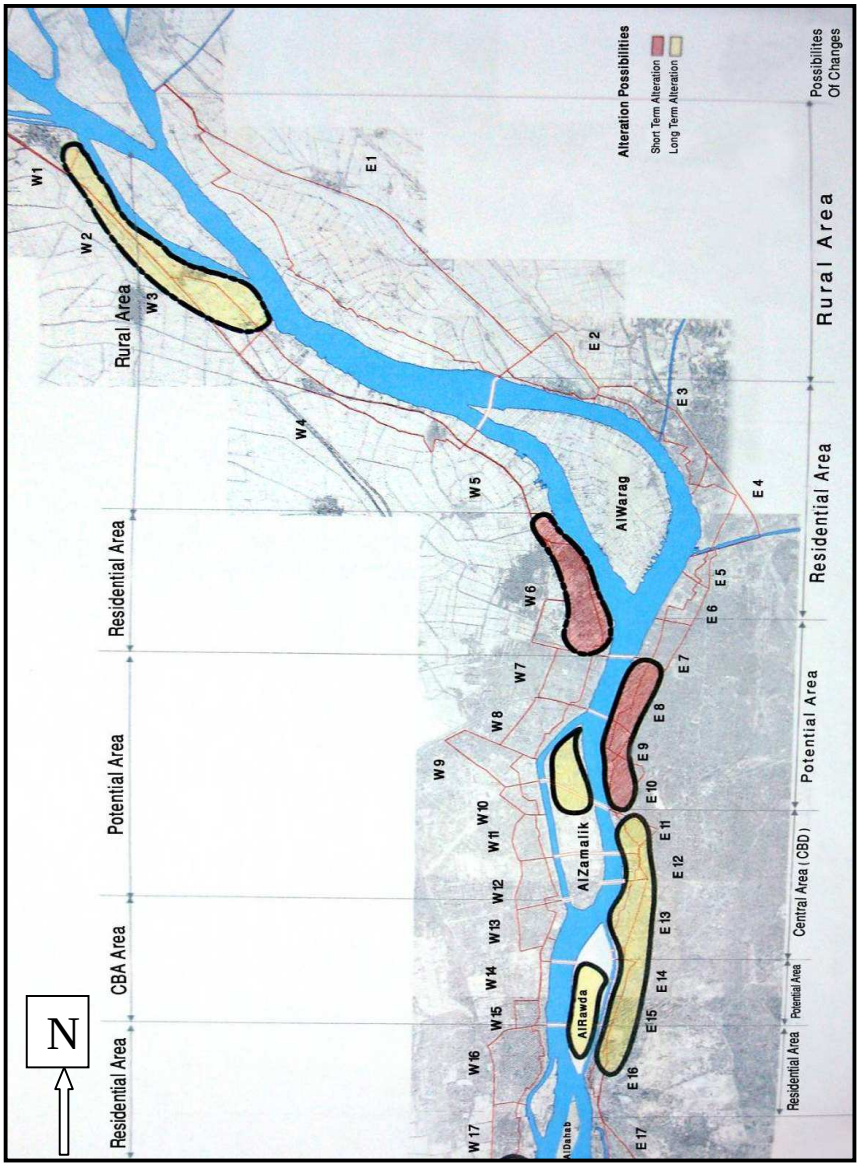


Fig 5-8 illustrates the Shores and their adjacent Riverfronts from Shore E1 and W1 on the East and West side of the Nile River to Shore E17 and W17 on the East and West sides of the Nile River in Greater Cairo.

Fig 5-9 Nile River Shores in Greater Cairo (source the Study for the Development of the Nile River Front at Greater Cairo 'March 2005, first book page 28' by University of Cairo)

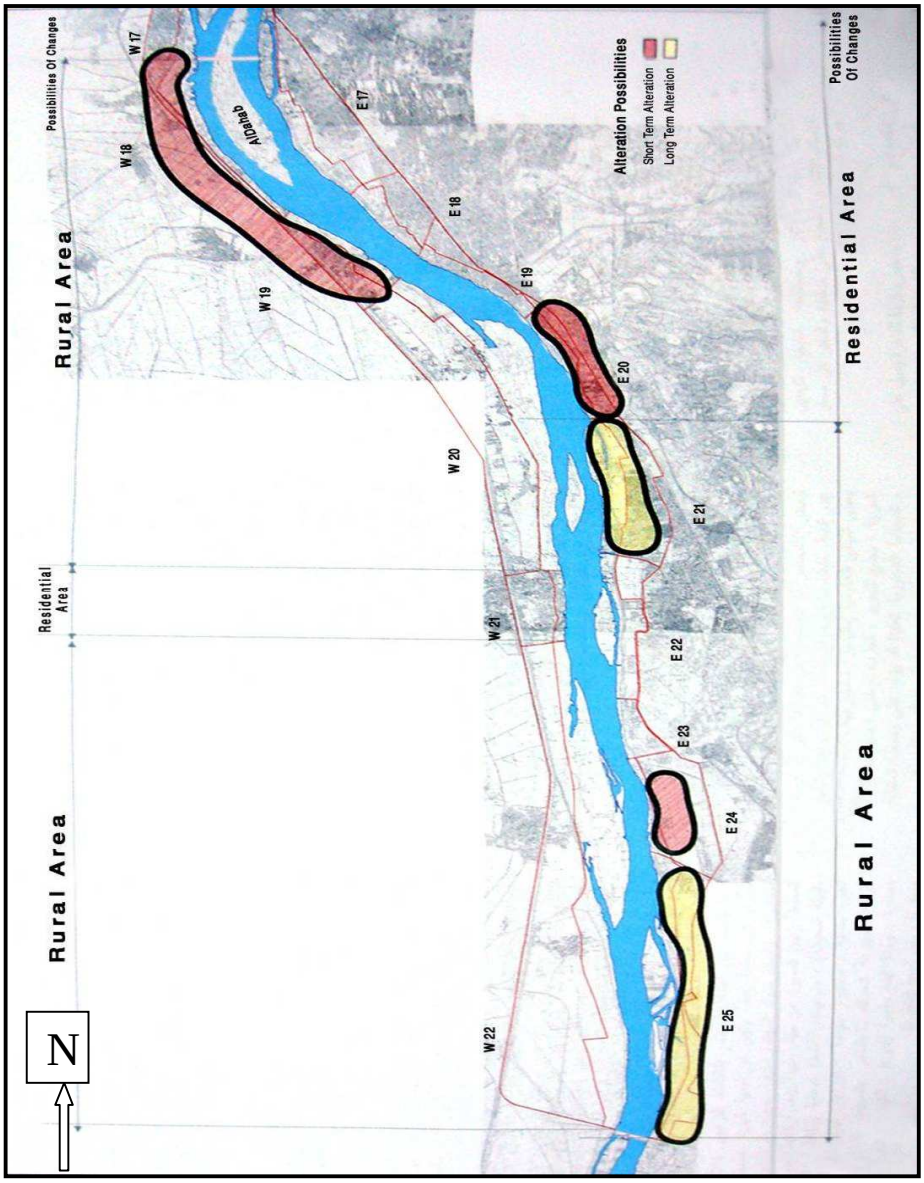


Fig 5-9 illustrates the Shores and their adjacent Riverfronts from Shore E18 and W18 on the East and West side of the Nile River to Shore E25 and W22 on the East and West sides of the Nile River in Greater Cairo.

5:4 Current Activities on the Nile Shores and their Riverfronts in Greater Cairo

The main current activities found on the Nile River Shores and the Riverfronts as adjacent areas to the Nile Shores in Greater Cairo as specified in the Study by the University of Cairo for the Development of the Nile River Front at Greater Cairo (2005) are specified in the section below:

5:4:1 Mix Use Activities

Mix use activities such as hotels, commercial areas, residential areas, tourist areas, recreational areas, leisure facilities and river harbours areas. These types of activities are founded on the East side of the Nile River on Shores E10, E11 and E12 while on the West side of the Nile River on Shores W13 and W15.

5:4:2 Service Activities

Different services are introduced to satisfy tourists and local people needs. These founded on the East side of the Nile River on Shores E4, E6, E8, E9 and E14 while on the West side of the Nile River on Shores W1,W8,W16,W17 and W21.

5:4:3 Urban Residential Areas for high, medium and low economic Groups Activities

Residential areas belong to high economic groups concentrated on the East side of the Nile Riverfronts E5, E13, E17 and E18 while on the West side of the Nile Riverfronts W10, W12, W15 and W19. The medium and low economic groups housing areas are located on the East side of the Nile Riverfronts E2, E3, E7, E9, E10, E15, E16 and E20 while on the West side of the Nile Riverfronts W1, W8, W16, W17 and W21.

5:4:4 Industrial Activities

The industrial areas are located on the East side of the Nile Riverfronts E3, E20 and E22 while on the West side of the Nile Riverfronts W4, W6 and W21.

5:4:5 Rural Areas Activities

Rural areas activities composed of rural settlements within agricultural fields located along Nile Riverfronts at the North and South sides of the urban areas in Greater Cairo. These activities situated on the East side of the Nile Riverfronts E1, E20 and E22 while on the West side of the Nile Riverfronts W3, W5, W18, W20 and W22.

5:4:6 Agricultural Areas Activities

Agricultural Areas are founded along the Nile River adjacent to the Nile Shores and the adjacent areas as Riverfronts in Greater Cairo. Most of these agricultural areas are located on the West side of the Nile River on W1, W2, W4 and W22 while on the East side are found only on Shore E1. Also there are agricultural areas found at the North Shores of Al- Warag and Al-Dahab islands.

5: 4:7 Recreational Areas Activities

Recreational areas are located on the East side of the Nile Riverfronts E4 and E19 while on the West side are located on the Riverfronts W9 and W11. Also there are recreational areas on the North and West sides of Al-Zamalik and Al-Warag as the main river islands.

5:5 Role and Values of the Nile River in Sustainable Development for Greater Cairo

The Nile River is a main characteristic of Greater Cairo and plays a significant role in social, economical and environmental issues for the population from ancient history till today. This because it has significant impact on sustainable development elements due to the Nile River values as summarized below:

5:5:1 Environmental Values

Nile River is the most open area within Greater Cairo which represent one third of total greater Cairo area 1500 acres as specified in the study by the University of Cairo for the Development of the Nile River Front at Greater Cairo DNRFGC (2005). This area absorbed polluted airs that occurred from the high density of the population concentrated on the Nile Riverfronts and improve the city environment. Nile River improves the environment of greater Cairo because the river is a main source of water for different uses (drink, agriculture, and drainage), ecological improvements and open air.

5:5:2 Recreational Values

The Nile River play significant role in recreation. Therefore most of recreational activities are located along the river such as urban parks, hotels, amenities, sports, leisure activities etc. Greater Cairo considered one of the high density cities in the world. The only greenery and open area is the Nile River. International standard of greenery and open space per one person is ranging between 10 - 18 m2 but in Greater Cairo is 1.5 m2 which represent one tenth of the international standard as specified in DNRFGC (2005). Below tables and charts illustrates the United Nations Environmental Programme (UNEP) standard of green areas within some international cities.

Table 5-1 Distribution of population and green areas in Urban Area in Cairo (source Greater Cairo Province 2000 page 29)

Greater Cairo Communities	Area of Recreational facilities / Acres		Population	Population rate m^2/ per person
	No	Area		
Cairo West	9	174	106920	6,82
Cairo Middle	8	18	142249	0,3
Abdeen	2	6	81790	0,31
Al-Waily	2	62	162164	1,6
Nasir	3	4	174199	0,096
Al-Moski	7	10	29562	1,46
Al-Sharia	6	2	62012	0,15
Al-Saida	20	18	161496	0,49

Greater Cairo Communities	Area of Recreational facilities / Acres		Population	Population rate m^2/ per person
	No	Area		
Al-Khalifa& Al-Maktum	21	17	19751	3,8
Old Cairo	2	158	236523	2,8
Al-Madi	3	58	142405	1,73
Hilwan	12	243	555842	1,83
Al-Tbeen	18	37	129209	1,22
Al-Basateen & Dar-Alslam	12	39	689794	0,24
Masr-Aljdeeda	12	226	125125	7,6
Al-Nozha	7	230	160282	6,03
Mdinat-Nasr	23	316	407952	3,72
Ain-Shams	7	36	485610	0,31
Al-Mataria		11	515767	0,08
Alsalam	12	74	369117	0,84
Al-Murg		1	260215	0,016
Shubra	23	18	86625	0,92
Rwadat Al-Farag	23	16	184253	0,38
Al-Sahil	3	61	345377	0,74
Al-Shrabia	19	23	255917	0,39
Al-Zaitoon	23	63	334470	0,8029
Al-Guba	3	28	314917	0,48
Al-Hamra	3	15	316661	0,2
Total		2004	7034161	1,2

Table 5-1 illustrates the lack of green areas related to the high population of Cairo and concentration of these recreational areas at Cairo West.

Table 5-2 Comparison between London and Cairo comparing ratios of the city area, green area and population density (source Physical Planning Corporation for Greater Cairo, 2003).

City Name	Population In Millions	City Area/ Km2	Population Density No of Persons/ Acre	Area in M2/ one Person from city area	Area in M2/ one Person from total Green area	Ratio of one person in city area comparing to Cairo	Ratio of one person in Green area comparing to Cairo
London	7.4	1500	22	199	29	6	20
Cairo	10.6	350	130	33	1.5	1	1

Table 5-2 illustrates the small area of Greater Cairo with high population and vice versa to Greater London.

Fig 5-10 Comparison of Green Area between European Cities and Cairo source DNRFGC (2005) p. 31

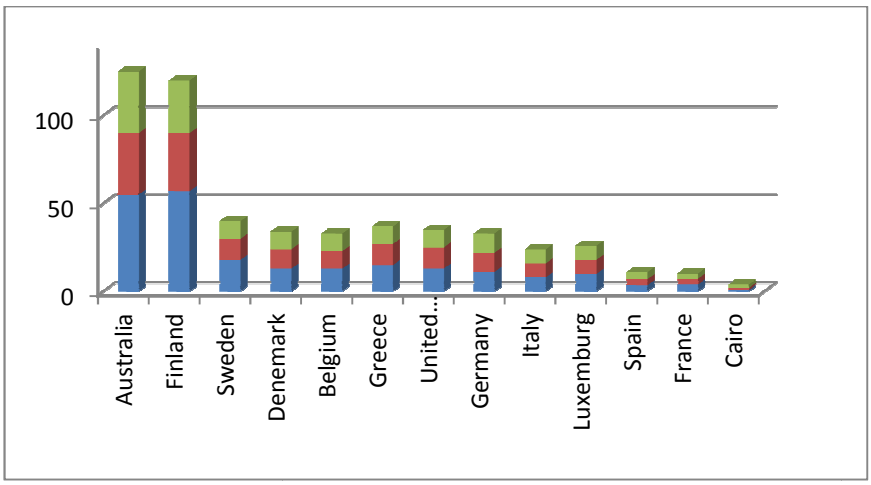


Fig 5-10 illustrates that Cairo has small green areas comparing to European and Australian cities.

Fig 5-11 Comparison of Green Area for each person in Egypt and some third world countries source DNRFGC (2005) p.31

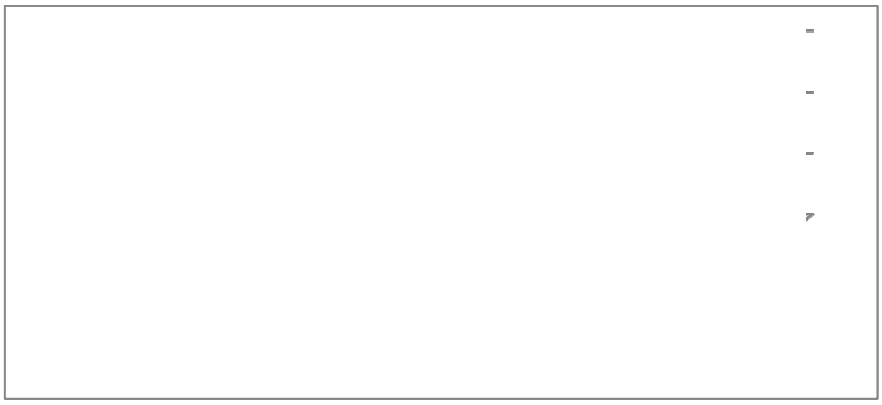


Fig 5-11 illustrates that there is small green area for the Egyptian people comparing to those in the third world countries.

5:5:3 Visualization and Beautification Values

Nile River in Greater Cairo offers diversification values such as vision and beauty of water, green areas along the river, sky line of the riverfront and vision of open areas. These areas along the Nile River according to the skyline and landscape assessment zones composed of:

- Red zone areas that composed of absolute outstanding beautiful areas such as river islands, cornice, river main stream. These red zone areas should be protected from any alteration so as to offer beauty to the whole city.
- Yellow zone areas composed of medium beautiful areas such as some recreational areas on the Nile shore, some amenities on river shore and some parks on river shore. The yellow zones areas are the most potential areas that can be developed and modified for attaining more beautiful areas.
- Green zone areas composed of potential areas of less beautiful such as the unutilized areas along the river front which can be developed for offering beauty to the city.
- Red doted zone areas composed of agricultural areas which should be protected from any sort of alteration.

5:5:4 Tourism Values

Most of the archaeological features of the ancient civilization from thousands of years were located along the Nile River extended from Geeza to Hilopolice and from Sagra to the Islamic city. Most of tourism activities in Greater Cairo were located on the Nile River such as hotels, water sports, picnics, cultural activities, parks, zoos, recreational activities and urban activities.

5:5:5 Economic Values

There are a lot of economic activities located along the Nile River where some of them are compatible with the river and depend on it, while others are odd. The compatible economic activities in the Nile River in Greater Cairo are such as river transportation methods, parks, river sports, fisheries and recreational. The odd activities found on the Nile River and polluted it are such as Hilwan Industries, Nile Cruises and floating restaurants. The floating activities contribute in local and national economy of Egypt where many people works in these activities. The floating activities are in continuous increase such as floating hotels which they are increased from 18 hotels in 1978 to 250 in 2000, while the capacity of the hotels rooms increased from 5,1000 rooms in 1990 to 136,000 rooms in 2003 (source DNRFGC , 2005 p. 43).

5:5:6 Greenways System Values

The study taken by the University of Cairo and Ministry of Tourism (May,2005) for the Development of the Nile River Front in Greater Cairo DNRFGC as strategic vision for greenways system in Greater Cairo is based on the function and value of the Nile River in Greater Cairo as specified in below sections:

5:5:6:1 Goals of the Greenway System in Greater Cairo

The study for greenway system in Greater Cairo will satisfy the following three basic goals:

- Networks system goals in the development plan will be satisfied by elimination of traffic congestion on Cornice Street by creating new parallel streets, creation of new transmission points and to make Cornice Street only for the users of the Nile River waterfront activities.
- To satisfy the environmental and recreational goals by protection of the Nile River from pollutions, protection of agricultural areas, protection of conservation areas and creation of greenway system in Greater Cairo.
- To satisfy social and economical goals by accessibility to the Nile Riverfront should be permitted to all, satisfaction of population demands and increasing of land values.

The Greenway System in the strategic development plan for Greater Cairo is based on the function and value of the Nile River as main blue way system. The Greenway System in Greater Cairo extended on both sides of the Nile River as illustrates in the overall development plan Fig 5-12.

Fig 5-12 Strategic Plan for Greenway system in Greater Cairo (source DNRFGC, 2005 third book p.25)

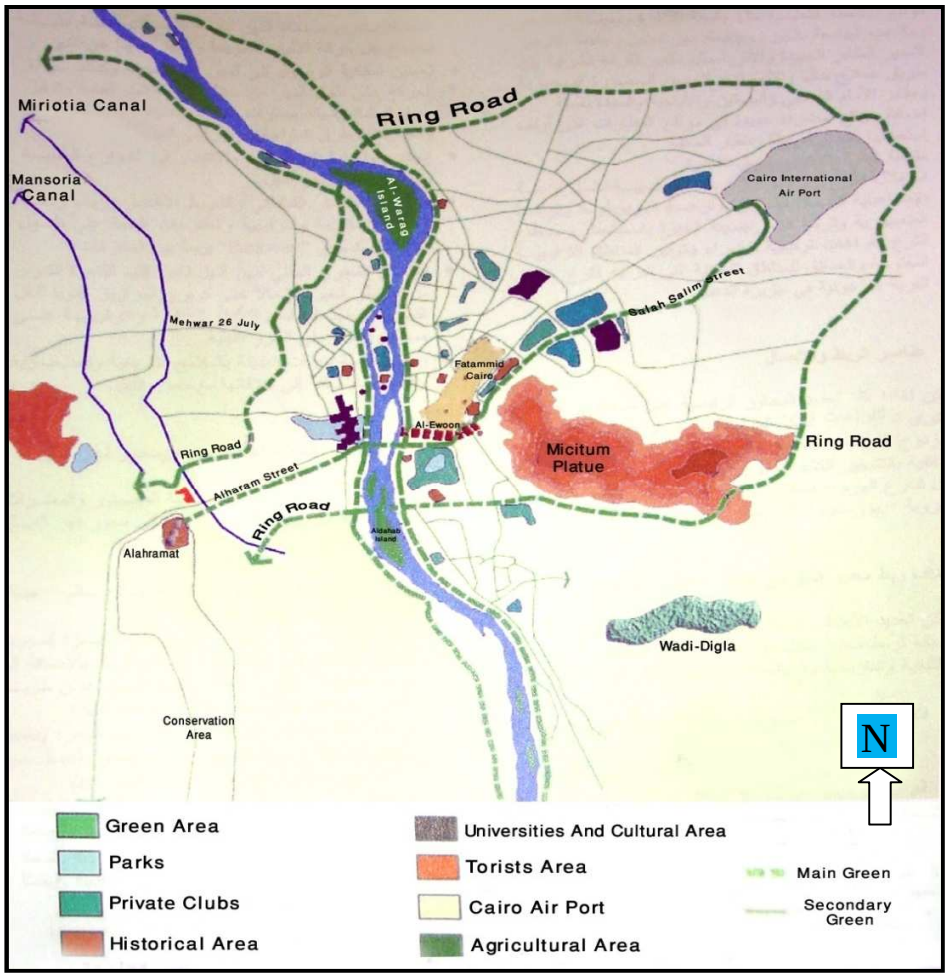


Fig 5-12 illustrates the general strategic development plan for greenway system in Greater Cairo within the overall development plan of Greater Cairo.

5:5:6:2 Potentialities of Greenway System in Greater Cairo

Potentialities of greenway system in Greater Cairo can be obtained from the following attractive elements:

- Appearance of the Nile River.
- Historical heritage and buildings from thousands of years.
- Conservation areas in Greater Cairo.
- Appearance of agricultural farms.
- Diversifications of the natural environment in Greater Cairo.
- The appearance of public and private recreational areas in Greater Cairo
- The cultural and tourists areas.
- The appearance of the Cornice along the Nile River.

5:5:6:3 Elements and components of Greenway System in Greater Cairo

Greenway system in Greater Cairo composed from the following elements:

- Blue way of the Nile River as main open corridor in Greater Cairo
- Cultural and historical greenways such as the pyramids in El-Giza, Salah-Eldeen castle, historical heritage buildings, cultural clubs, historical palaces as main and sub points for greenways system in Greater Cairo.
- The recreational greenway system in Greater Cairo can composed of main attractive recreational points such as open parks, big hotels, public zoos, main sports areas (Olympic stadium), main river sports points, main footpaths and sub attractive points distributed between these main recreational points such as small gardens, small hotels, sub river sports points, sub footpaths, sports areas, open recreational areas.
- Ecological greenway system in Greater Cairo can be composed from the main natural attractive points such as natural ecological conservation areas along the Nile

River shores and islands, natural trees and farms, the Nile River ecology, fauna and open rural areas.

The overall system of the greenway system in Greater Cairo is illustrates in Fig 5-13

Fig 5-13 Strategic Plan for the development of the Nile River Front for Greenway system in Greater Cairo (source DNRFGC, 2005 third book p.27)

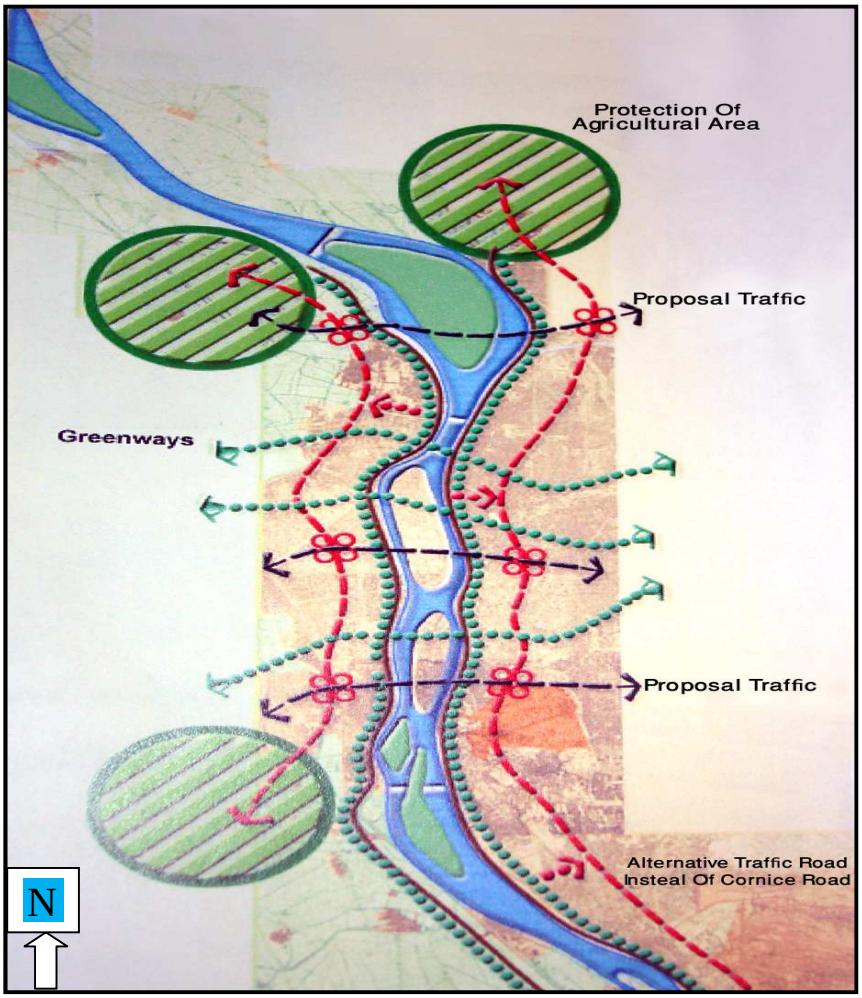


Fig 5-13 illustrates that, the main attractive and hip points that support greenway system in Greater Cairo are located on both sides of the Nile River.

5:6 Development of the Nile River Front in Greater Cairo in the study by the University of Cairo in (2005)

The study of the Nile Riverfront by the University of Cairo in (2005), tackles the development of the main stream, river shores and riverfronts of the Nile River in Greater Cairo. The study specified the development of the various activities along the Nile River. Some of them are adapted to the river and hence to be protected, modified or created. Others are odd and pollutant and hence to be removed and altered with new adapted ones as summarized below:

- Development of homogenous areas on the Nile River Shores and the adjacent areas on the Nile Riverfronts. The homogenous areas composed of agricultural areas, recreational areas, residential, industrial areas and mixed use areas.
- Development of existing recreational and tourist's areas.
- Planning of the existing Nile River transport and cruises stations to cater for new and modern Nile Cruises and transportation methods.
- Establishing new harbours and stations for the Nile Cruises at Asr-Alnabi and the CBD area.
- Establishing modern and scientific methods for long and short trips.
- Integration of the Nile River transportation methods with the other type of transportations.
- Encouraging the Nile River transportation methods to eliminate grey transportation methods that increase pollution in Greater Cairo.
- Planning of new hotels on both sides of the Nile Riverfront.

The development plan of the Nile Riverfront in this study by the University of Cairo (2005) is illustrated in Fig 5-14

Fig 5-14 Development of Tourism Strategic Plan along the Nile River Front in Greater Cairo (source DNRFGC, 2005 third book p.34)

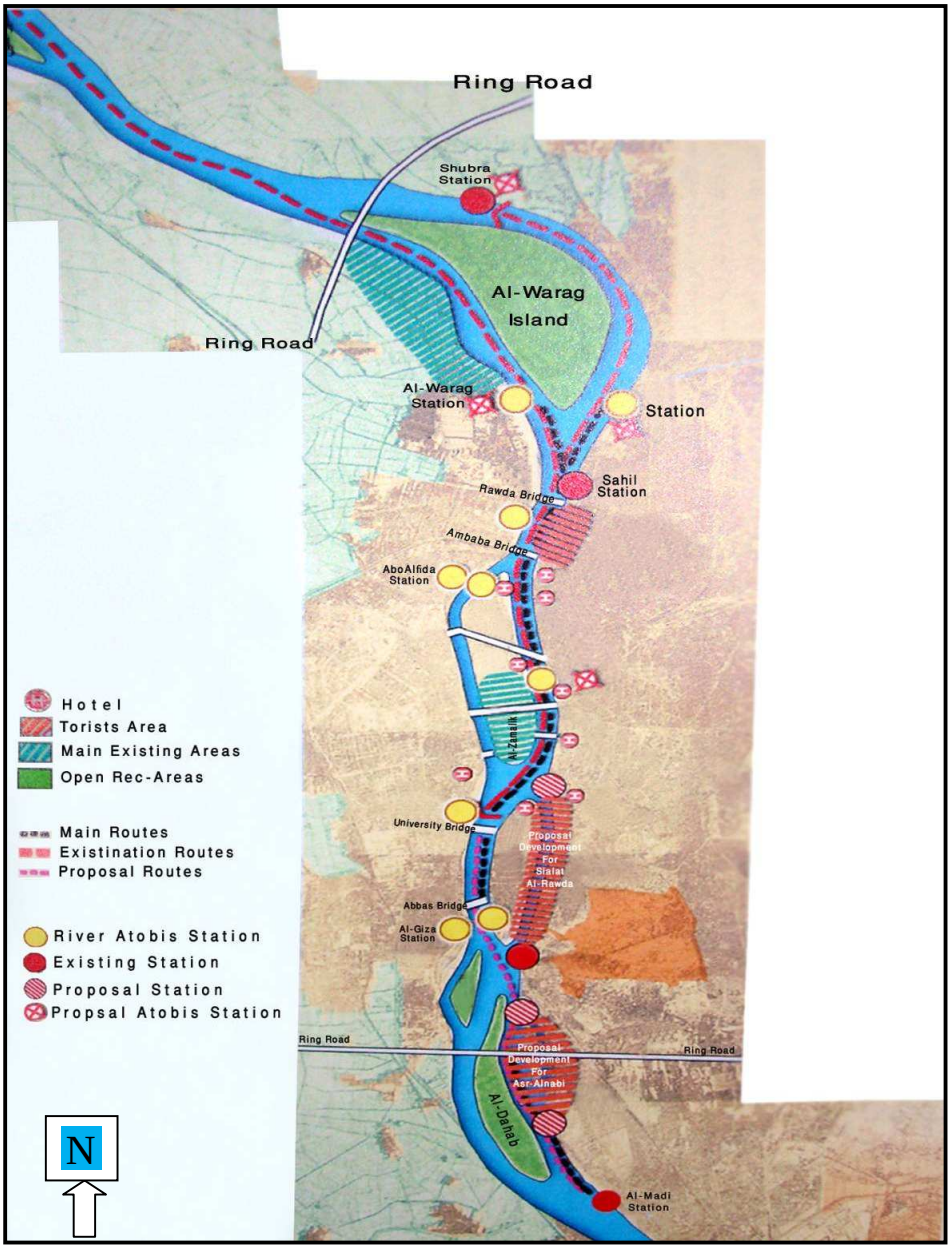


Fig 5-14 illustrates that the use of the Nile River as main blue way and traffic route in the development of the Nile River Shores and the adjacent areas to them on the Riverfronts in Greater Cairo.

5:7 Development of Potential Shores in Greater Cairo

The study of the Nile Riverfront by the University of Cairo in (2005), tackled the development of the Nile River Front and the Nile River Islands in Greater Cairo with special consideration for the following potential areas as summarized below:

5:7:1 Development of the Nile River Front at Asr- Alnabi

The area of Asr-Alnabi is 180 acres on the East side of the Nile River in Cairo Province between Masr- Aljdida and Al-Madi. The length of the Nile River Front is 1650 m with average width of 50 m. The study for the potentiality of the study area advice to be developed for recreational, tourists and water sports activities. This type of development will be applied to the study area for the following reasons:

- Appropriated length of the Nile River Shore in the study area.
- Suitable accessibility to the site from Cairo Ring Road, Hilwan Road and Metro Road (Hilwan-Al-Warag).
- Good sightseeing of the agricultural farms in Abu-Aldahab River Island.
- Openness of the Nile River in the study area.
- The direct connection of the study area with the main Nile River Cornice.

The current situation of the study area composed of warehouses, stores, cars garages, and small commercial areas. The current situation is illustrates in Fig 5-15.

Fig 5-15 the current situation of Asr- Alnabi study area (source DNRFGC, 2005 third book p. 44)

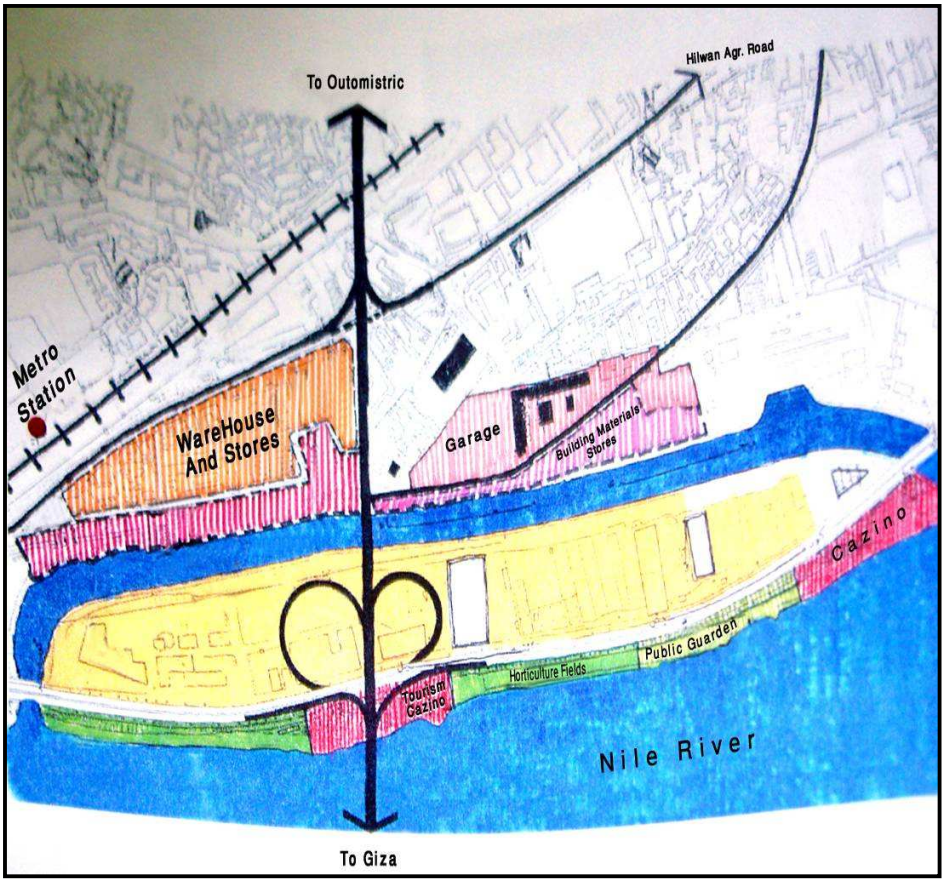
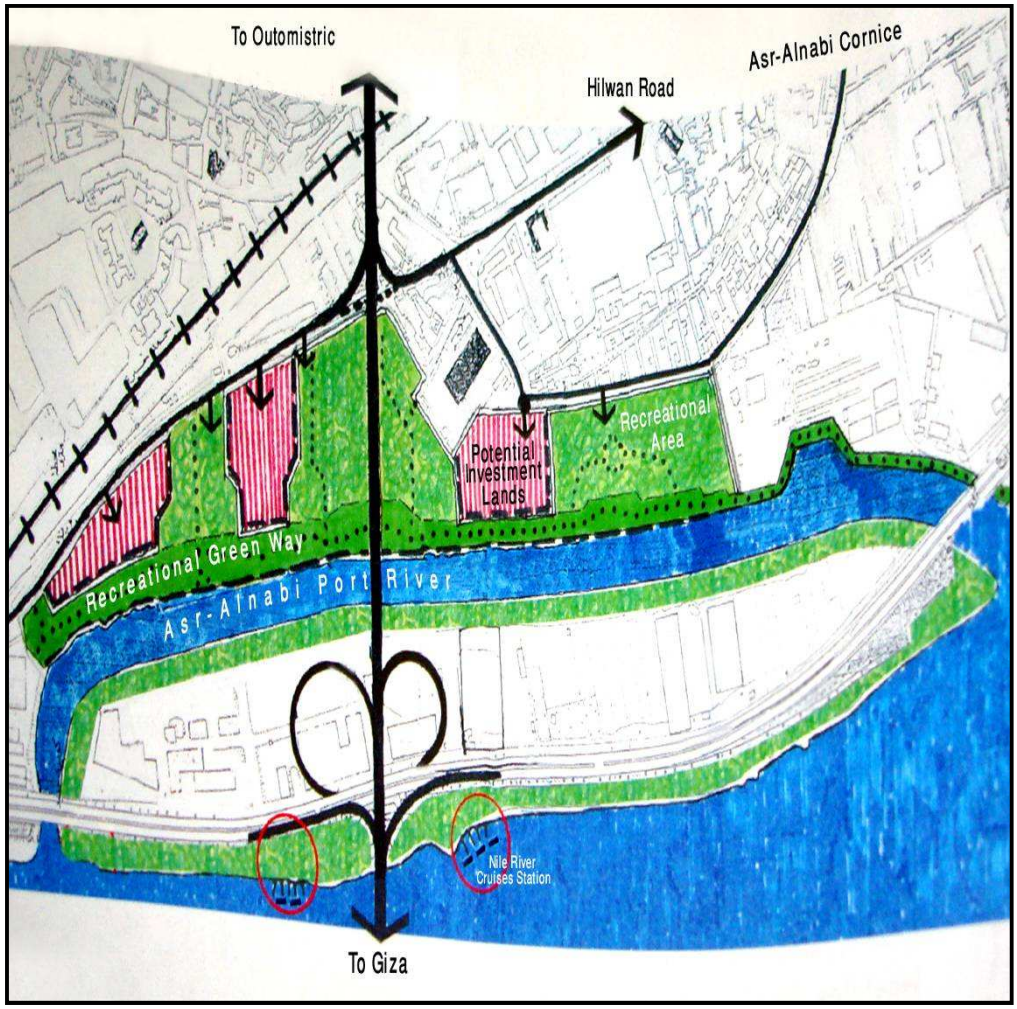


Fig 5-15 illustrates that the current activities found on the warehouses and garages are polluted the Nile River and they are odd and not adapted to it.

This potential area tackles in the study carried by the University of Cairo in 2005 for the development of the Nile River Front in Greater Cairo as case study. The main elements in the proposed development plan for this potential area are as illustrates in below Fig 5-16.

Fig 5-16 the new proposed development plan for Asr- Alnabi study area in Greater Cairo (source DNRFGC, 2005 third book p. 45)



The proposed development plan for Asr-Alnabi will be implemented in two stages as illustrated below Fig 5-16.

Fig 5-17 the stages of the proposed development plan for Asr- Alnabi study area in Greater Cairo (source DNRFGC, 2005 third book p.46)

Fig 5-17 illustrates that the land uses in the proposed development for Asr- Alnabi are composed of green, recreational areas and landscape that incorporates artificial water.

5:7:2 Development of the Nile River Front at Sialat Al-Rwada

The total length of the Nile River Shore at Sialat Al-Rwada is 3 km and the width of the study area range between 10 to 30 m. Summary of the study for development of the Nile River Front by the University of Cairo in 2005 for this area is as specified below:

5:7:2:1 Potentialities of the study area

Sialat Al-Rwada is the second case study in the study carried by the University of Cairo in 2005 for the development of the Nile River Front for the following reasons:

- The historical buildings in the study area such as Babylon tower, Minstrels palace from khedive Said period, Mohammad Ali royal palace at Al-Rwada garden and Cairo castle.
- The Ancient Nile River measurement at the South side of Al-Rwada Island from Abaci period and the Seven Swagi canals irrigation system for the castle gardens from Mamluke period.
- The Ancient religious buildings such as Cairo suspended church and Amr-Ibn –Alas mosque from Abaci period.
- The Existing Nile River cornice.
- Appearance of the Nile River in the study area.
- Appearance of diversification agricultural fields.

5:7:2:2 Main problems in the study area

The main problems and barriers restricted the development in this study area are as specified below:

- Deterioration of the Nile River Shore in the study area.
- Inclination slope of the Nile River shore in the study area.
- Traffic congestion in the study area.

- Bad condition of the cornice (without seats, without parking, without trees and greenery)
- Bad sightseeing of the Nile River due to the bad utilization of the shore and pollution resulted from the deterioration of the Nile River in the study area.

5:7:2:3 Main Recommendations for the study area

The proposed development plan will consider the following recommendations:

- Creation of river parks system within the whole greenway system for Greater Cairo.
- To design footpaths along the Nile River due to the narrow shore .
- Protection of existing trees along the Nile Cornice and establishing new landscape elements.
- Creation of new harbors and stations for Nile Cruises, boats and Nile transportation methods.
- Development and maintenance of historical and conservation areas.
- Development of the existing cornice in the study area particularly at Garden City and Masr-Aljdeeda.

5:7:3 Development of the Nile River Front at Rwdat Al-Farag

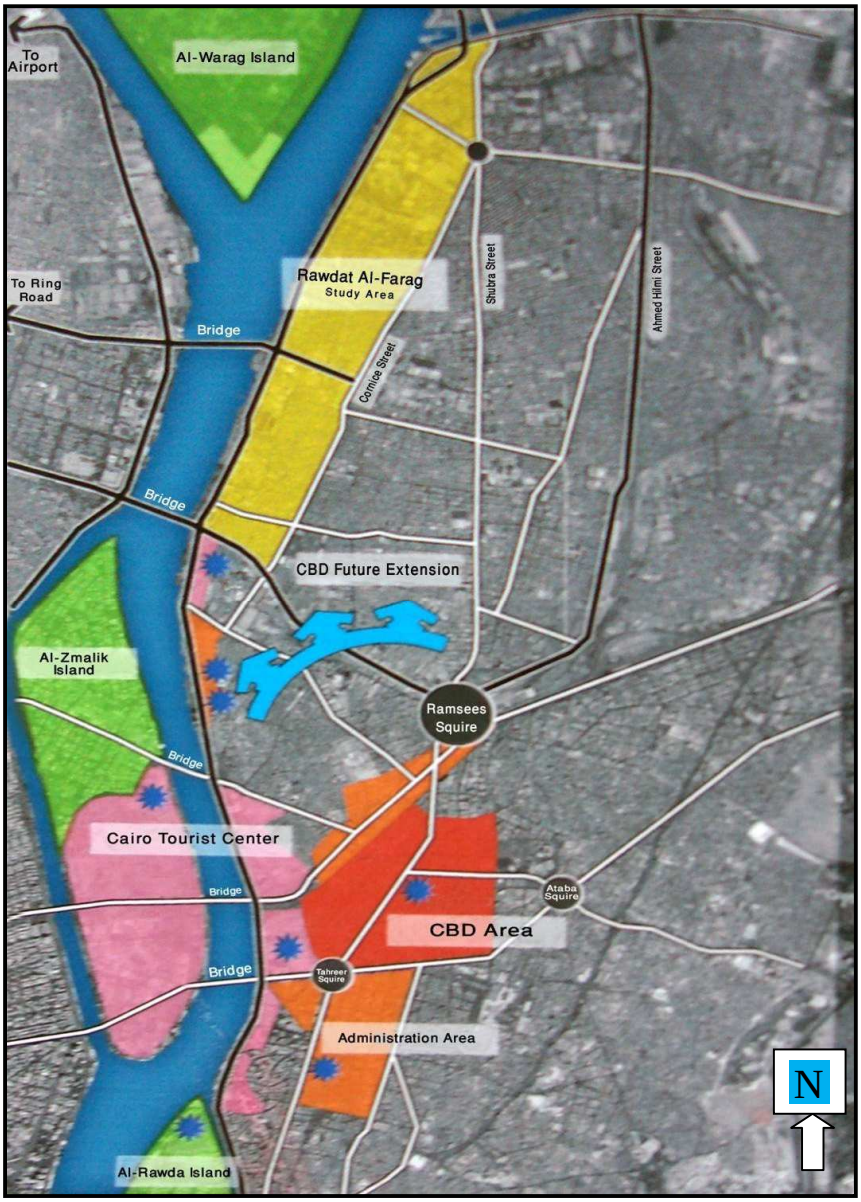
The development of Rwdat Al-Farag is the third case study area in the study carried by the University of Cairo in 2005 for the development of the Nile River Front in Greater Cairo. The land uses in the study area are of continuous alteration and changes due to the high potentiality and characteristics of this area. From the essential location of the study area the new development can cater for commercial centers, five stars hotels, recreational and tourists activities. The study gives special consideration for the area to be as model and scenario for the development that can be applied to other similar areas along the Nile River in Greater Cairo. The study gives special consideration for the Nile River as summarized below:

- Development of the Nile River Shores to cater for open public parks.

- Development of the Nile River Front to cater for recreational, commercial, tourists and river sports activities to create greenway system in Greater Cairo.
- Proper utilization of the Nile Riverfront.
- Creation of new stations and harbours along the Nile River Front for Nile Cruises, boats, river transportation and recreational methods.
- Connection of residential areas in the depth of the Nile River Front with the Nile River Shore by using greenway system in Greater Cairo.
- Establishing alternative traffic routes for the Cornice Roads such as Gasr- Albhar Street (18-22 m wide) and Obaid Street (15-18 m wide).
- The study advice for the cornice street should be stopped at the North of Akha- Khan Towers and circulated around the main national park.
- The study advice for the main street that comes from Shubra should be connected with Gasr- Albhar and Obaid Street.

Fig 5-18 illustrates that the development of Rwdat Al-Farag is connected with the future extension of Cairo CBD Area and the function of the Nile River.

Fig 5-18 Location of Rwdat Al-Farag (source DNRFGC, 2005 third book p.34)



5:8 General Observations of the Author

General observations of the author to the Nile River Front in Greater Cairo from his visits to Cairo are as specified below:

5:8:1 Water Management of the Nile River

Before the construction of Aswan High Dam in 1968 many problems are occur such as erosion, sedimentation, floods, mud slides that resulted from the high discharge of the flow water in flood season and the low discharge in dry season. These problems restrict the development of the Nile River Front particularly in Greater Cairo. These problems are solved due to the management of the flow and discharge water of the Nile River which is released by the Ministry of Irrigation based on the seasonal irrigation needs in the Nile Delta and the other consumption demands as specified in below Table 5-3.

Table 5-3 Monthly Irrigation Release requirements from The Aswan High Dam (source DNRFGC, 2005 first book P. 47)

Month	Jan	Feb	Ma	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Release in Billion M3	3.5	4.0	4.2	4.0	5.3	6.5	7.0	6.3	4.3	3.7	3.6	3.0	55.4

The Aswan High Dam (AHD) is 3600 m long, 980 m wide at the base , 40 m wide at the crest and 111 m high. The AHD has 12 electro- hydraulic turbines with annual capacity of 2.1 GW (Giga Watts).

The water level at the back of the dam ranges between 36 m in dry season and 77 m in flood season while the water level is stable at the front of the dam due to the manageddischarge of water. Sedimentation material is sediment in the lake of Aswan High Dam Reservoir which

extended for 500 Km long and 12 Km wide with the depth of 15 -100 m of annual capacity of 162,000 Million M3 divided as specified below:

- 31,000 million m^3 dead storage for sedimentation material below the level of 145 meters above sea level.
- 90,000 million m^3 annual active storage water for the annual use between the levels of 145- 175 meters above sea level.
- 41,000 million m^3 emergency storage water between the levels of 175- 182 meters above sea level.
- Any extra discharge water above the level of 182 meters above sea level will be discharged to Tushki Canal.

5:8:2 Sustainable Protections of the Nile River Shores

The Nile River Shores in Greater Cairo are divided to 61 sectors most of them are protected by masonry walls, brick walls, concrete walls and few shores without protection or protected with natural trees. The general conditions of these shores are illustrates in below Photos:

Photo 5-1 Photograph illustrates sustainable protection of the Nile River Shore by masonry walls and paved footpaths (source the author)

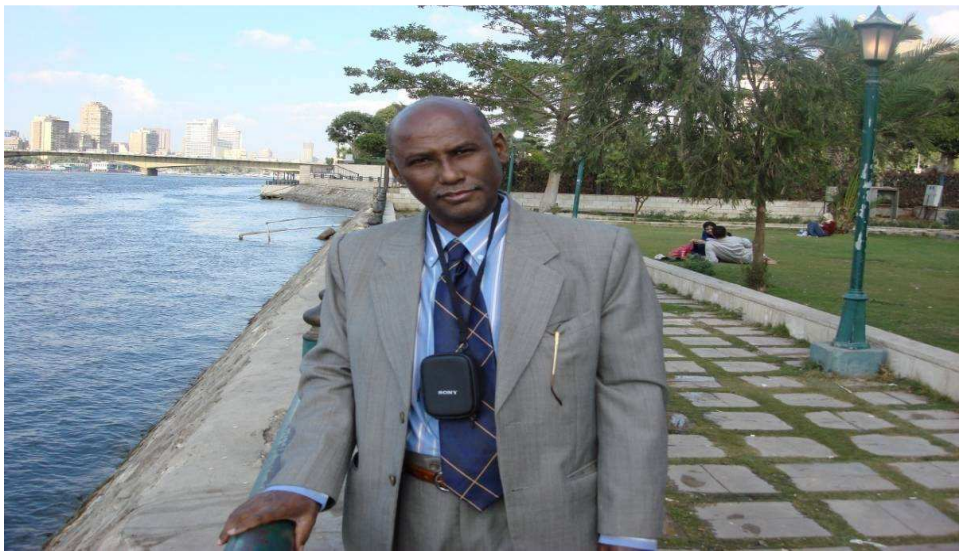
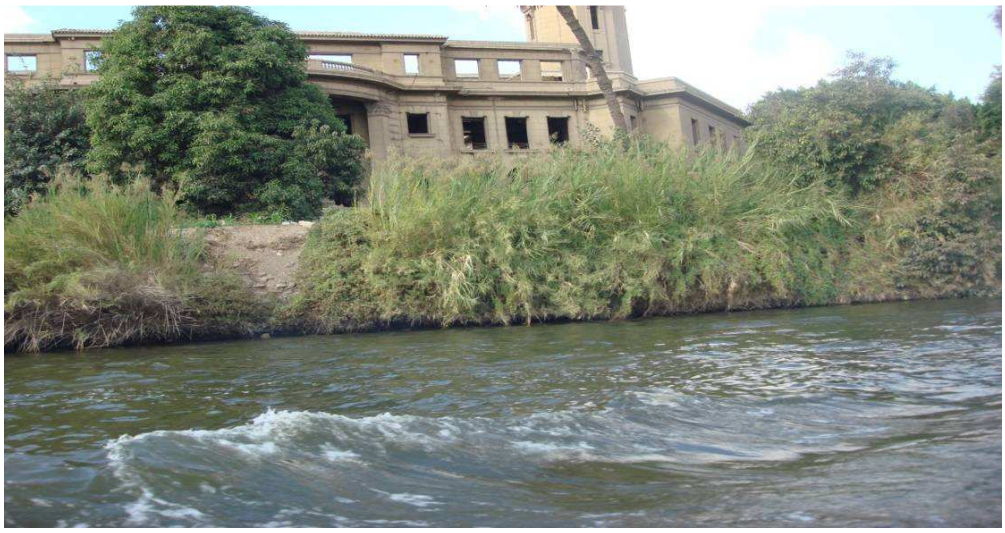


Photo 5-2 Photograph illustrates sustainable protection of the Nile River Shore by masonry walls without footpaths (source the author)

Photo 5-3 Photograph illustrates sustainable protection of the Nile River Shore by concrete walls and suitable height steel fence (source the author)

Photo 5-4 Photograph illustrates Protection of the Nile River Shore by brick walls that required more sustainable protection (source the author)

Photo 5-5 Photograph illustrates Protection of the Nile River Shore by natural trees that required sustainable stabilization (source the author)



5:8:3 Accessibility to the Nile River Front

The Nile River Front should be accessible to all without restriction or constraints according to regulations, laws, and legislations that applied to the Nile River Front. These legislations issued from Ministry of Council in Egypt such as 43 in the year 1975, 95 in the year 1977, 918 in the year 1982, 135 in the year 1984 and Greater Cairo Regulation for the development of the Nile River front in the year 1999. These legislations and regulations specified the utilization of the Nile River Front, human right for accessibility to the river, fence height along the shore not to be exceeded than one meter high so as not to cause obstruction for the vision or sightseeing of the Nile River Front (source DNRFGC first book page 39, 92).

Some of these shores are deteriorated from bad utilization and others are not accessible as illustrates in below Photos:

Photo 5-6 Photograph illustrates the high rise building restricted accessibility and obstructed visualization of the Nile River Front (source the author)

Photo 5-7 Photograph illustrates the fence of private clubs that restricted accessibility and vision of the Nile River Front in Greater Cairo (source the author)

Photo 5-8 Photograph illustrates the fence of private horticulture farms that caused restriction for accessibility and vision of the Nile River Front in Greater Cairo (source the author)

5:8:4 Sky Line of the Nile River Front in Greater Cairo

In spite of legislations and building regulations which direct the development of the Nile River Front in Greater Cairo we can see bad sightseeing, town sprawl and sky line of Greater Cairo along the Nile River Front as illustrates in the below photos:

Photo 5-9 Photograph illustrates the differentiation in building height along the Nile River front in Greater Cairo (source the author)

Photo 5-10 Photograph illustrates the city sprawl of Greater Cairo along both sides of the Nile River Front (source the author)

Photo 5-11 Photograph illustrates the high rise building in the Nile River beside Greater Cairo Tower (source the author)

Photo 5-12 Photograph illustrates the differentiation in building height along the Nile River Front in Greater Cairo (source the author)

5:8:5 Pollution to the Nile River Front in Greater Cairo

Stipulated legislations and laws are restricting and not permitting pollution to the Nile River. Pollution occurs from high polluted activities such as factories, warehouses, some river cruises, disposal from some restaurants, oils from some boats, traffic pollution as illustrates in below photos:

Photo 5-13 Photograph illustrates pollution from restaurants disposal along the Nile River Shore (source the author)

Photo No 5-14 Photograph illustrates pollution from floating restaurants, Nile Cruises, ships and boats along the Nile River Shore (source the author)

Photo 5-15 Photograph illustrates pollution and obstruction from fixed floating Nile Clubs (source the author)

Photo No 5-16 Photograph illustrates pollution from river transportation methods (source the author)

5:8:6 Good Utilization of the Nile River Front

Good utilization of the Nile River Front in Greater Cairo occurs from those activities adapted with the river and raises its beautification and visualization value. These activities such as open parks, green areas, river navigation, river recreational activities and Nile Cruises as illustrates in below photos:

Photo 5-17 Photograph illustrates open Public Park with public footpaths and good accessibility and vision of the Nile River Front along Cairo Cornice (source the author)

Photo 5-18 Photograph illustrates Public Park (source the author)

Photo 5-19 Photograph illustrates Public Park and footpath (source the author)

Photo 5-20 Photograph illustrates good utilization of the Nile River in transportation in Greater Cairo (source the author)

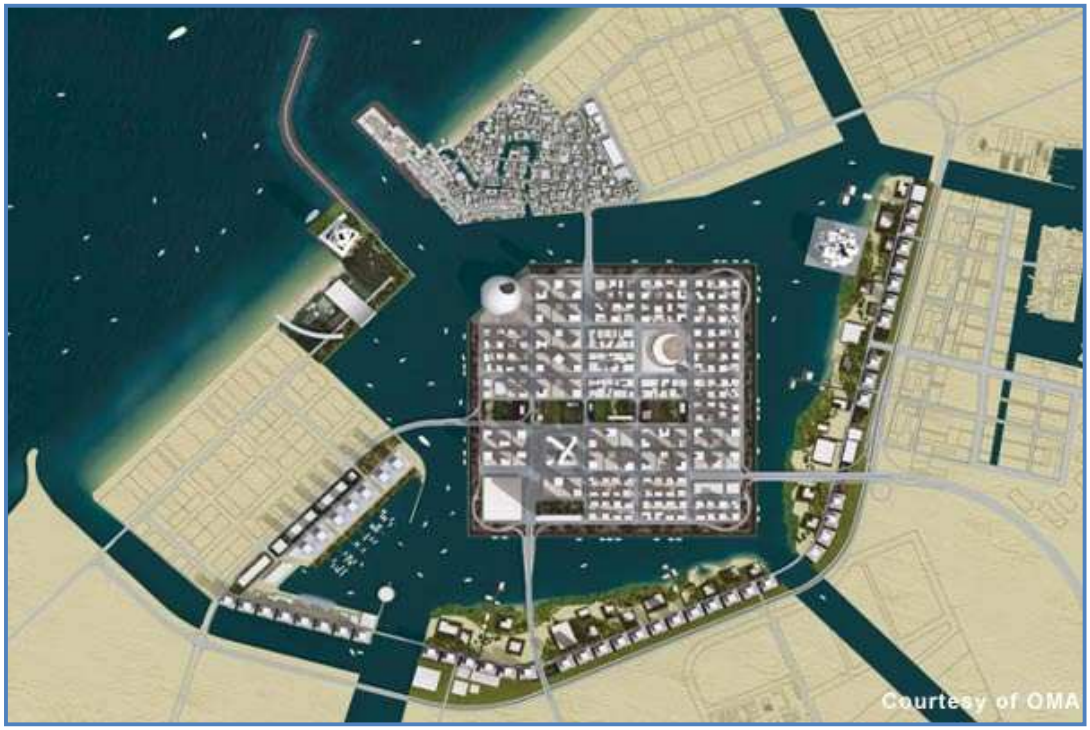
5:9 Examples of Others Case Studies in the World

This section illustrates examples of some waterfront treatments in the world that highlighting how the waterfront treated as specified below.

5:9:1 Dubai Waterfront Development

In March 2008 the master plan for the new waterfront city in Dubai was completed by the Office for Metropolitan Architecture OMA. The total area of the whole waterfront development is 140 km2 and provides new homes for 1.5 million people and creates one million new jobs. The waterfront development is composed of a series of artificial islands and canals. The development is curved around protecting the Palm Jabel Ali adding 70 km to Dubai coast line. The development constructed on a squire artificial island by the developer of Nakheel of Dubai Corporation that owned 51% of this project along with the Dubai Waterfront Company. The development composes of four islands surrounding the central square and is considered as part of the city. The central square will have a residential population of 92,000 and working population of 310,000 forming a lively centre for work and entertainment. The total gross floor area in the central square is 1,180,000 m2 on square shaped Central Island. The central square island is surrounded by four neighboring districts of the Boulevard parks and Boulevard ring road for main access to the three sides of the central square island. The other four islands incorporated with this development are namely; Canal, Omran, Veneto and Badra. Badra is the first active gateway of the waterfront. The total development area in these islands is 7,000,000 m2. The development will have extensive transport system that linked to Dubai and Dubai International Airport by; metro, bridges and ring roads. The development is considered as a part of maximum shading and climate control. The overall concept is illustrated in Fig 5-19.

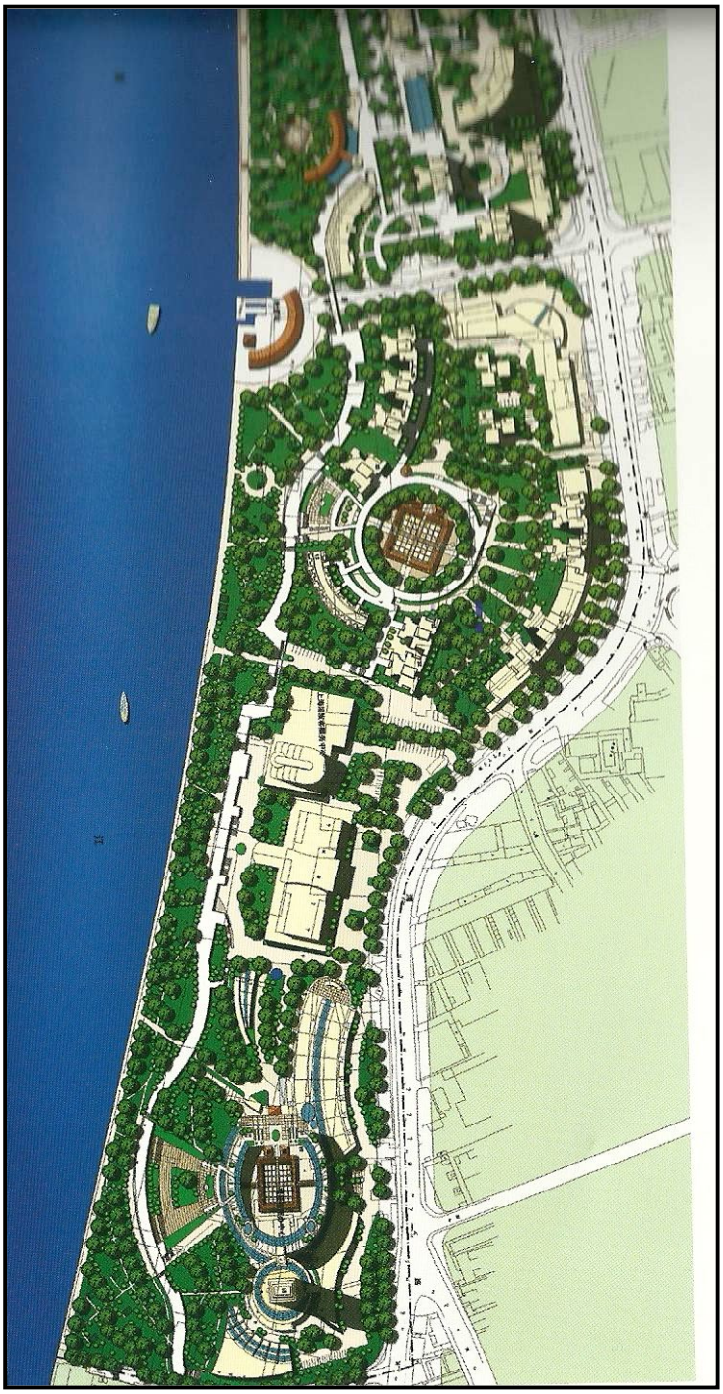
Fig 5-19 Dubai Waterfront Development (source www.dubaiwaterfront.net)



5:9:2 Shanghai Gaoyang and Huishan Harbor Waterfront Development

This development is located on Damin Road along Huangpu River in Shanghai in China. The total area of the development is 49.4 hectares. The scope of the development is to create a continuous common urban space of activities on the riverside and to establish unique riverfront urban sincerely. The concept of the design highlighted; accessibility to riverfront, continuity of activities, richness of space, transverse extension and special features of this area. The development has important value for tourism, improvement of urban environment and special appeal to surrounding regions. The development is illustrated in Fig 5-20.

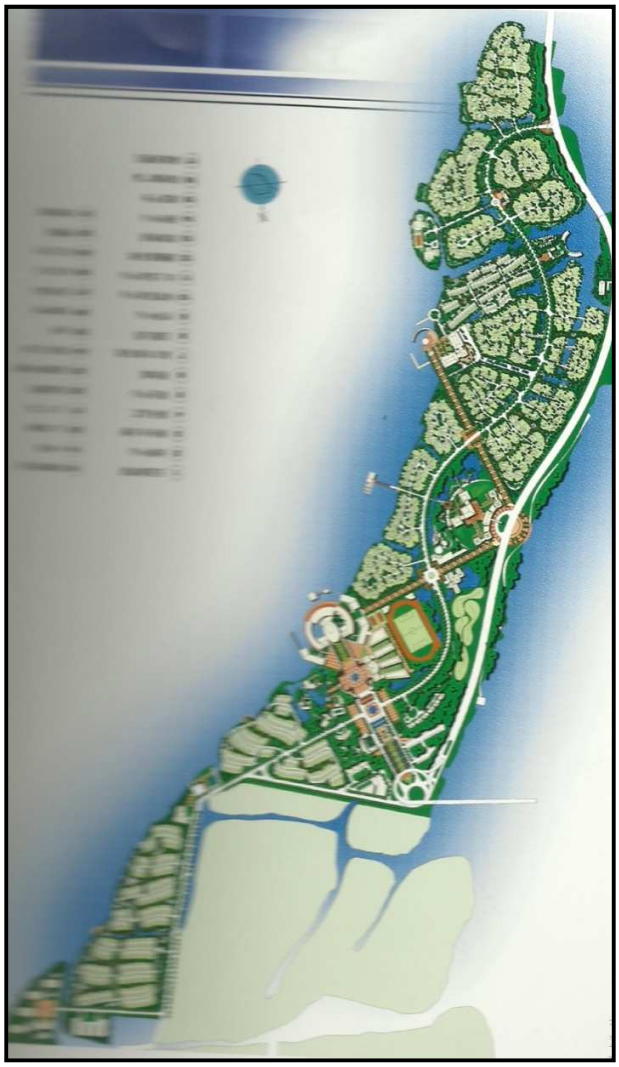
Fig 5-20 Shanghai Gaoyang and Huishan Harbor (Source East China Architectural Design Institute ECADI page 240 by China Architecture & Building Press March 2002)



5:9:3 Waterfront Developments for Suzhou Huaqing Yangcheng Lake Vacation Village

The development is invested by Huaqing Times Investment Group Co. Ltd developer in 2001. The total floor area of this development is 335,000 m2. The development is located on the south end of the Banding Land in the middle of Yangcheng Lake. The development is formulated for leisure and recreation as illustrated in Fig 5-21.

Fig 5-21 Suzhou Huaqing Yangcheng Lake Vacation Village (Source East China Architectural Design Institute ECADI page 244 by China Architecture & Building Press March 2002)



5:9:4 City of Malmo in Sewed Waterfronts Development

The development built on waterfront area at Vasta Hammen stretching towards Copenhagen in the 1990s. The site was chosen to host the city of tomorrow that aimed to focus on ecological sustainable living in the developing information and welfare society. The development contains two green park areas, waterfront promenade, marina and various sheltered areas within the site. The development contains water course canal runs through the site from North to South where a wooden area called the Willow Forest was created on the North- East portion of the site in which ten hidden gardens were located together integrated with other landscape features including outdoor sculptures. This urban development evolving higher styles of sustainable city living. This concept is illustrated in Fig 5-22.

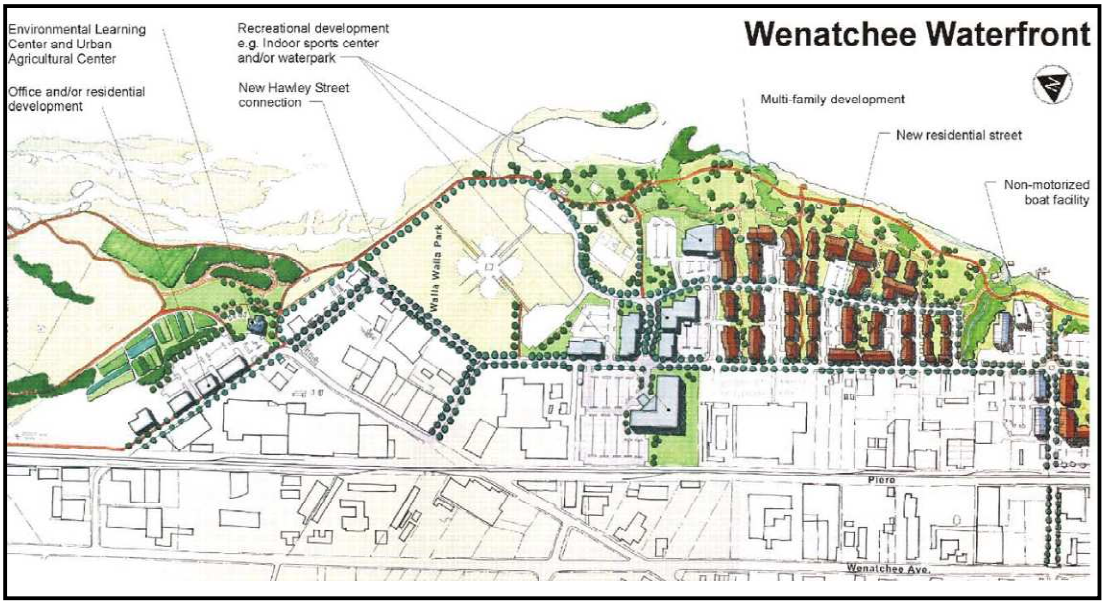
Fig 5-22 Aerial view of Malmo Waterfront (source Sustainability and Profit Plate 28)

ate 28: Bo01: Aerial view of Malmö showing the site (Göran Rosberg/Ronny Bergström, Malmö City Planning Offices)

5:9:5 Wenatchee Waterfronts in China

The development for Wenatchee Waterfront was addressed for implementation in 2003 by Chelan County Public Utility for sustainable development. The development composed of; parks, open spaces, recreation and mixed- use elements. The development divided to three nodes within short, medium and long term periods. The North Node integrates new residential neighborhoods within recreational development in the three periods. The Central Node creates recreational, retail and mixed- use elements that focus on parks attraction within the three periods. While the South Node creates boating and water based activities within the short, medium and long term periods. The concept is illustrated in Fig 5-23

Fig 5-23 Wenatchee Waterfront (source wenatcheewaterfront.net)



5:9:6 New London Waterfront Developments in England

The New London Waterfront Development is the civic open space along Thames Riverfront. Historically the area formed continuous barriers between the city and the riverfront due to active water dependant's users and the railroad corridor. The River Thames has played a crucial role in London as a great international city in the world and as the hub of Britain's Empire. The initial planning for New London Waterfront Development studies were undertaken in 1997 and construction has been implemented in phases between1998-2002. Now New London Waterfront Development gives the city its unique personality. The development is integrated between the historical characteristics and the modern sustainable development elements that give the identity of Greater London City. The concept illustrated in Fig 5-24

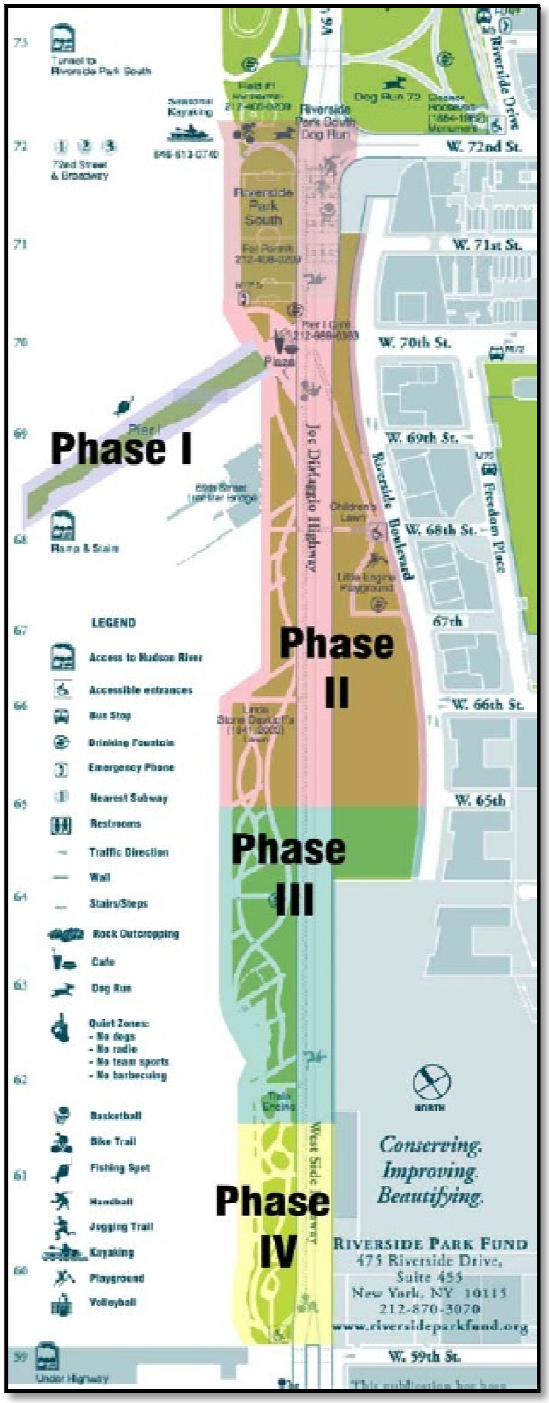
Fig 5-24 New London Waterfront Developments in England (www.londonwaterfront.com)

5:9:7 New York Waterfront Developments

The waterfront development in New York in USA composed of many projects along Hudson River. One of these projects was the Riverside Park South. The park is a new urban development along Hudson River at the West Side of Manhattan between 72 and 59 streets. The project implemented in phases where phase I completed in (2001), phase II in (2003), phase III in (2006) and phase IV in (2008). The development is a unique vision for modern concept for sustainable waterfront development in urban cities. The development is suitably designed to provide for a variety of active and passive recreational facilities to its users. Also the development contains different types of waterfront elements such as; plaza, seating areas, cultural areas, community activities and various water based activities. The development of the Riverside Park South has strong connection with its pedestrian and its surrounding areas. The vision is illustrated in Fig 5-25- 27

Fig 5-25 & Fig 5-26 illustrated the New York Waterfront Development (source DNRFGC, 2005 third book p.4)

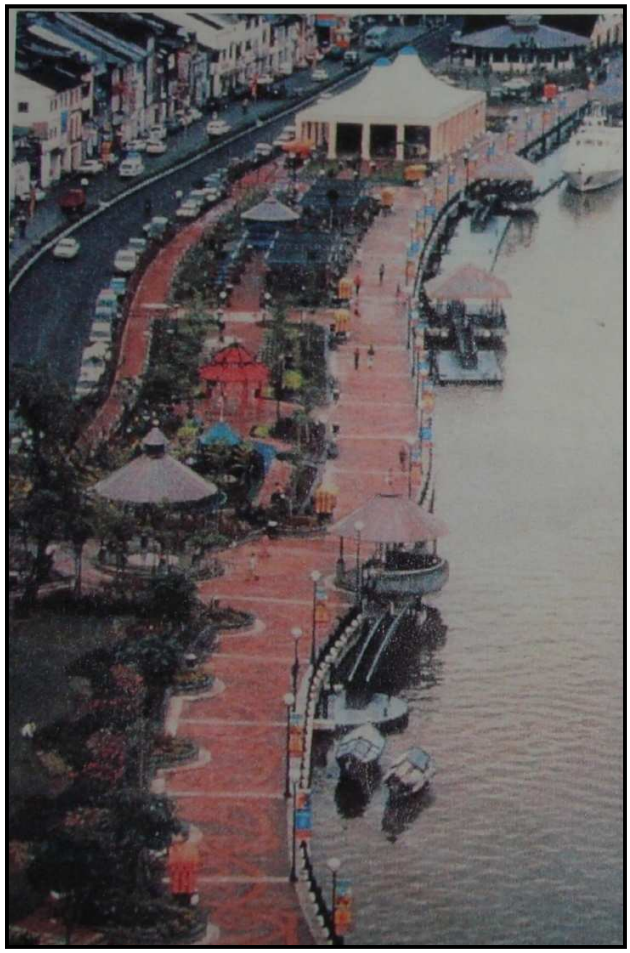
Fig 5-27 Phases of New York Waterfront Developments (source Anuja, K. (2009) *Waterfront in Urban Cities*. MSc thesis, University of Tax as in USA)



5:9:8 Kotshing Waterfront Developments in Malaysia

The Kotching City is located on Saroak River in Malaysia. The development of waterfront in Kotching city is creating new urban elements along the riverfront that integrated with the unique characteristics of the city. The development composed of, recreational, commercial and mixed use elements along the river that offering distinctive services. The panoramic view of this development is illustrated in Fig 5-28.

Fig 5-28 Panoramic view of Kotshing Waterfront Development (source www. Kotchingwaterfront.com)



5:9:9 Kuala Lumpur Malaysia

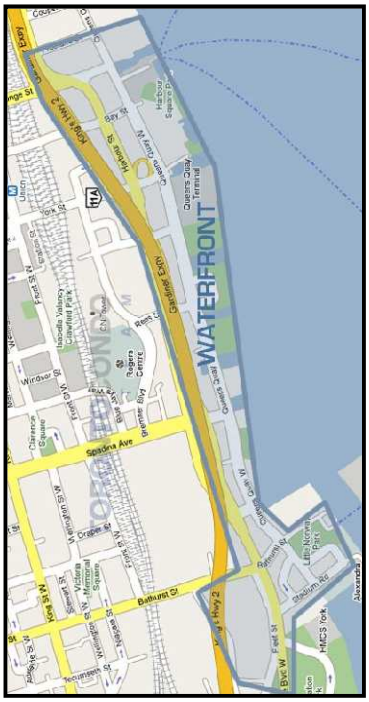
Kuala Lumpur Development in Malaysia was designed according to conceptual approach in tropical climate. The concept influenced by; sustainability, tropical techniques and hierarchy of development elements. The development is an urban concept that creating fingers of development towards waterfront that integrated with green parks and landscape elements. The concept is illustrated in Fig 5-29

Fig 5-29 Kuala Lumpur Waterfront in Malaysia (source kualalampurwaterfront.net)

5:9:10 Toronto Waterfront Developments in Canada

Toronto Waterfront Scan in Canada has been established as strategy study to assist the government of Canada to create a comprehensive overview and integration of environmental issues and opportunities related to Revitalization Development. The development is grounded in a sustainability context of environmental, social and economic determinants, but with a clear focus on environmental sustainability that considering ratification of the Kyoto Protocol. This concept is illustrated in Fig 5-30 and Fig 5-31.

Fig 5-30 & Fig 5-31 illustrated the Toronto Waterfront Development in Canada (source torontowaterfront.net)



5:9:11 Karachi Waterfront Developments in Pakistan

Karachi Waterfront Development KWD in Pakistan is new benchmarks in commercial, residential, recreational and retail property. The total development area is 108 acres that implemented between 2006 and 2008. The concept was creating a unique coastal frontage that using innovative design and construction techniques related to sustainable development. The concept is illustrated in Fig 5-32 and Fig 5-33.

Fig 5-32 Panoramic View for Karachi Waterfront (source karachiwaterfront.net)

Fig 5-33 General View for Karachi Waterfront (source karachiwaterfront.net)

5:9:12 California Waterfront Developments in USA

The development of the waterfront in California along Filgo River in United States of America is a sustainable integrated approach that applied for developing riverfront. The development composed of; public and private activities such as; parks, hotels, concert conference halls, sport clubs, recreation and marinas. The development is illustrated in Fig 5-34

Fig 5-34 California Waterfront Development Plan in USA (source DNRFGC, 2005 third book p.13)

5:9:13 Gas Works Park Waterfront Developments in Washington

Gas Works Park in Washington in United State of America is one of urban park in Greater Washington. The main objective of the development was to integrate the historical industrial plant with modern landscape and recreational elements. The development area is accessible from its surrounding areas such as; Lake Union on the East, Police Harbor on the West and Wallingford neighborhood on the North. The modern development elements are incorporated with historical ones such as the Gas Works Plant. The development also featured with the artificial hill known as the “Great Mound”. The development provides adequate opportunities

for active and passive recreation as well as fantastic views of the skyline of downtown. The development is illustrated in Fig 5-35 and Fig 5-36.

Fig 5-35 Gas Works Park Waterfront Developments in Washington (source Anuja, K. (2009) *Waterfront in Urban Cities*. MSc thesis, University of Tax as in USA)

Fig 5-36 Panoramic View for the Gas Works Park Waterfront Developments in Washington (source Anuja, K. (2009) *Waterfront in Urban Cities*. MSc thesis, University of Tax as in USA)

5:9:14 Sharjah Waterfront Developments

Sharjah Waterfront Development is a unique urban development under construction and it will be implemented in 2012. The project is located on the Khalid Lagoon as a tourist and resident urban development to United Arab of Emirates. The project composed of recreational and cultural areas integrated with unique landscape elements that forming comprehensive sustainable planning strategy for Emirate. The concept is illustrated in Fig 5-37.

Fig 5-37 Panoramic View for the Sharjah Waterfront Development (source www.sharjahwaterfront.net)

5:9:15 Tokyo Waterfront Developments

Tokyo Waterfront Development is located along Tokyo Bay Coastal City that forms the city axis area together with Yokohama, Kawasaki and Chiba. Tokyo Waterfront is extended 6 km from downtown of the city along the bay. The development is connected with the other regions such as; Haneda Airport, Narita and the region by railways and roads. The development composed of recreation, cultural and mixed use facilities incorporated with nice landscape. The concept is illustrated in Fig 5-38 and Fig 5-39.

Fig 5-38 Panoramic View for Tokyo Waterfront Area (source www.tokyowaterfront.net)

Fig 5-39 Tokyo Waterfront Site Plan (source www. tokyowaterfront.net)

5:9:16 Paris Waterfront Developments

Paris Waterfront Developments is composed of; recreational, commercial, water based integrated with nice landscape along Seine River in Greater Paris. The developments of the Seine Riverfront are characterized with the integration of the historical features or landmarks such as; Eiffel Tower, Notre Dame Cathedral, Arch de Triumphed Paris, Pictus Cemetery, Place de La Pastille Paris and Louvre Museum with the modern areas. The concept of the integration of the past and the present gives Paris its identity as a unique city in the world. The vision is illustrated in Figs 5-40, 5-41 and 5-42.

Fig 5-40 Paris Waterfront Developments and Historical Landmarks on Seine Riverfront (Source www.paris **touristmaps.com)**

Fig 5-41 Paris Tourist Maps (source www.paristouristscorporation)

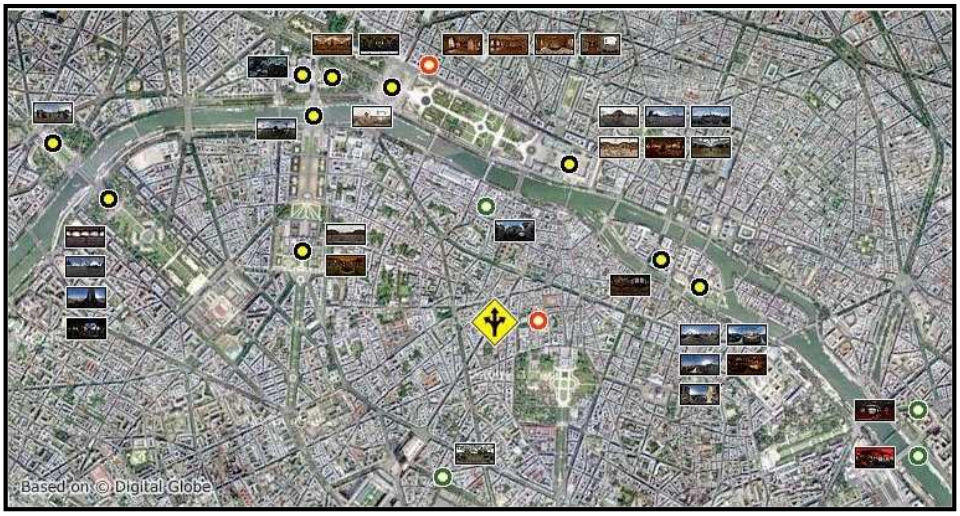


Fig 5-42 Seine Waterfront Development (source www.pariscitywaterfront.com)

5:9:17 Oklahoma City Waterfront Developments

The development for Oklahoma City downtown waterfront is located along 1500m of Oklahoma riverfront on an area of 250 acres. The development is public open space along riverfront as a unique airpark. The unique Air Park is the dominant feature that connected the different urban elements of Oklahoma Waterfront Development. The development provide various riverfront activities including; civic events, cultural performances, recreation and respite. The Air Park is reuniting Oklahoma City with its riverfront and urban revitalization and growth. The concept is illustrated in Fig 5- 43.

Fig 5-43 Model for Oklahoma City Waterfront Developments (source www.oklahomawaterfront.net)

5:9:18 Chongqing Waterfronts Strategic Plan in China

Chongqing is traditional industrial city in China that located on Yangtze River. Chongqing Planning Council in April 2008 commissioned a vision for strategic plan for sustainable development of Yangtze River Waterfront in Chongqing city. The vision is to create a word renowned city characterized with its unique natural and cultural features by reshaping the waterfront. Also the vision aims to provide practical principles and guidance for sustainable urban strategies oriented with ecology and culture as integrated approach that required for rapid development in Chinese Cities. The challenge varies at three levels:

- Regional level that restore the ecological structure of big mountains water.
- City level which locate important cultural and public programs along entire waterfront.
- Site level that enhanced the existing waterfront landscape incorporated with modern elements.

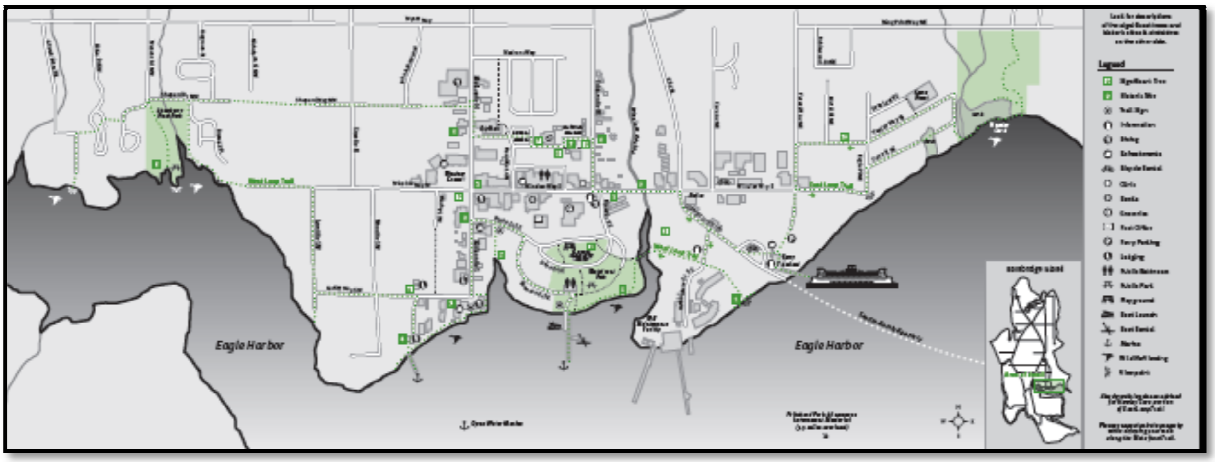
The concept is illustrated in Fig 5-44.

Fig 5-44 Chongqing Waterfronts Strategic Plan in China (source www. chinawaterfront.net on 10\9\2011)

5:9:19 Bainbridge Island Waterfront Developments in USA

Bainbridge Island historically was a harbor in United States of America where ships were built for to be used in the Second World War. The site now occupied by Washington State Ferries and developed as public space integrated with historical buildings and residential neighborhoods settlements. The Western Loop of this development composed of; public parks, restaurants, marinas integrated with the historical buildings. The Eastern Loop composed of residential neighborhoods units, marinas, cornice and water based recreational activities. The concept illustrated in Fig 5-45.

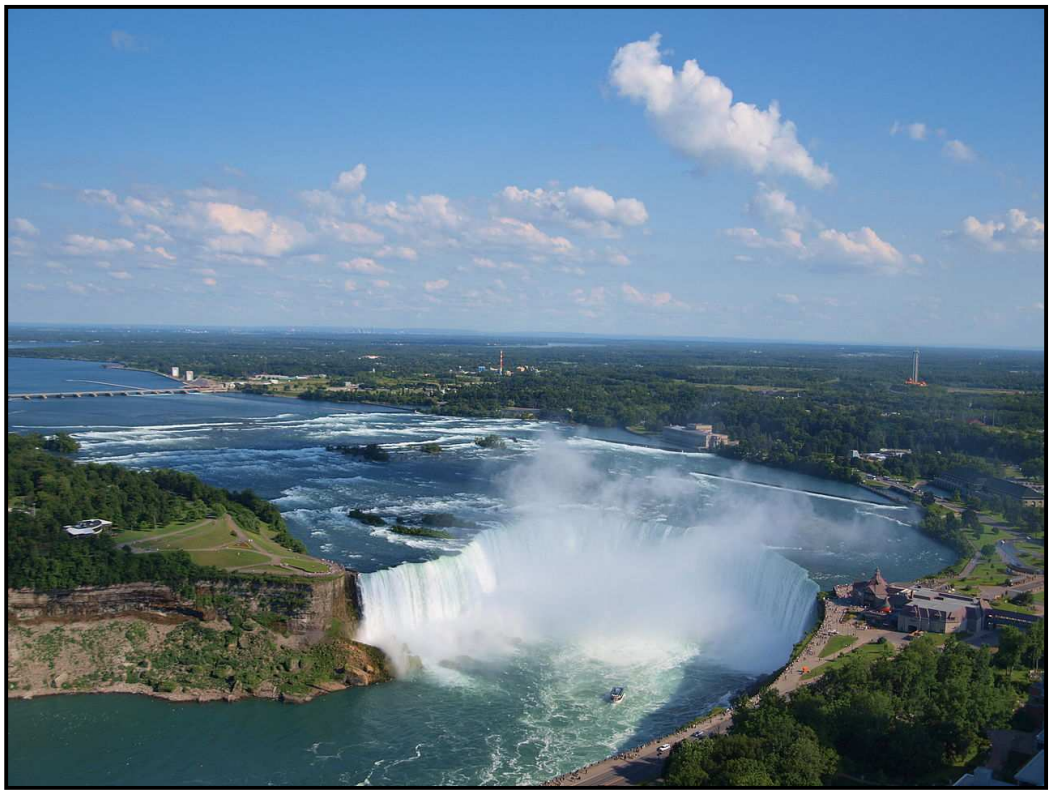
Fig 5-45 Bainbridge Island Waterfront Developments in USA (source www.watefront.net)



5:9:20 Niagara Waterfalls Development

The Niagara Falls Development is located at the international border between Canada and United State of America. It is composed of two major sections that separated by Goat Island. The first section is the Horseshoe Falls on the Canadian side and the other is the American Falls on the American side. The Niagara Falls is considered one of the highest discharge flows of waterfalls in the world that falls over the crest line. The Niagara Falls due to its high discharge flow is developed for hydroelectric power and for recreational and commercial elements. The concept is illustrated in Fig 5-46

Fig 5-46 panoramic view of Niagara Waterfalls Development (source www.nigarawaterfront.com)



5:10 Summary of Chapter Five

Chapter Five specified the justification and reasons for selecting Cairo as similar case study due to various similarities between Cairo and Khartoum as Nile cities. The chapter tackled historical background about Cairo from ancient civilization before Islam and after Islam. This from 640 AD when it was small military town called 'Fustad' until Cairo today. The historical background illustrates the development of Cairo and the significant role of the Nile River in the shape and the characteristics of Cairo. The chapter described the general specifications of the Nile River Shores and the adjacent areas to those Shores that called Riverfronts. These Shores with their Riverfronts were divided into 61 manageable Shores in Greater Cairo. The chapter specified the current activities on these Shores and the adjacent areas to them that known with the Riverfronts in Greater Cairo. The chapter specified the adapted activities to the Nile River that could be developed and planned and the odd activities that should be removed and altered. The chapter specified the role and values of the Nile River in sustainable development for Greater Cairo. These values of the Nile River are the environmental values that gained from the Nile as main blue way in Cairo, the recreational values where many recreational activities can be based on the Nile, visualisation values and the greenway system on both sides of the Nile River where this system is mainly based on the Nile River.

The chapter summarizes the study for developing the Nile River Front in Greater Cairo by the University of Cairo in 2005 as study taken for the development of the Nile River in Greater Cairo. The chapter specified the development of the Nile River Shores and their adjacent areas that known with the Riverfronts. The chapter illustrates the current situation and the development plan for these potential areas at Asr-Alnabi, Sialat Al-Rwada and Rwdat Al-Farag.

Finally the chapter specified the observations of the author due to his many visits to Greater Cairo. These observations illustrates with photos taken by the author were related to water management, stabilization methods, accessibility to the Nile and general characteristics of the Nile River Shores in Greater Cairo. The data derived from main case study incorporated with data derived from the other 20 case studies will be used as guidance for the development the Nile Riverfront in Greater Khartoum.

CHAPTER SIX: METHODS OF STABILIZATION

NILE RIVER BANKS

6:0 Introduction

Chapter six will develop a set of guidelines based on previous chapters the stabilization methods for each Nile River Banks in Greater Khartoum as first area in this study. The chapter will specify the main factors that affecting methods of protecting Nile River Banks in the study area. These factors will be related to:

- Environmental factors such as the hydrology of the Nile River, flooding, mudslides, erosion and infrastructure.
- Economic factors which will tackle the general economic situation of Sudan, the landownership and the local materials.
- Social factors that related to the legislations that required for sustainable development of the Nile River Front in Greater Khartoum and local skills.

The chapter will tackle Shore 3, 7 and part of Shore 9 with total length of 6.500 km as the only protected Shores from the 16 Shores with total length of 67.875 km of the study area. These three Shores also considered as the most potential and important Shores because they are facing the CBD area and most of the important and recreational activities in Greater Khartoum were located on them.

The chapter will develop a set of guidelines and specified the suitable methods for stabilizing each bank of the Nile River Banks as specified below:

- Methods of protecting Shores 1, 2, 6, 13 and 14 on the Blue Nile. These shores banks will be stabilized with concrete walls method, concrete and brick walls method and timber wood piling method.
- Stabilization methods for Shores 8, 15 and 16 on the White Nile which will be protected by raking bricks or masonry walls method, masonry on dry pitching earth embankment method and compacted earth embankment method.
- Methods of stabilizing Shores 9, 11 and 12 on the Main Nile which will be protected by Concrete walls method and concrete and brick walls method.
- Stabilization methods for the confluence Shores 4, 5 and 10 at Tuti Island which will be stabilized with concrete walls method, concrete and brick walls method.

6:1 Main Factors Affecting Protection of the Nile River Banks

Main Factors Affecting Protection of the Nile River Banks as specified in the previous chapters related to environmental, economic and social factors. These factors will be specified in the below sections.

6:1:1 Environmental Factors

Environmental Factors is the first type in the Main Factors Affecting Protection of the Nile River Banks which composed of five variables that specified the main problems and their impacts on river stabilisation banks as specified below:

6:1:1:1 Hydrology, Morphology and Geotechnical of the Nile River

Hydrology, Morphology and Geotechnical of the Nile River is the first variable of the Environmental Indicators. This variable composed of three elements that describe the characteristics of the Nile River and the impact of these characteristics on the methods of stabilisation banks. Nile River is alluvial meandering river composed of Blue and White Nile joining and confluence together at Khartoum forming the Main Nile River. Blue Nile is a main driving force because of the fluctuation variation in the discharge flow between dry and flood season of the Blue Nile due to the Ministry of Irrigation in Sudan Records for 50 years which is 10 Million m^3/ day in dry season and 700 Million m^3/ day in flood season, while White Nile is of stable discharge in dry and flood season that is of 73 Million m^3/day. The variation of water level between dry and flood season is 7.82 m, 7.45 m and 8.06 m for Blue, White and Main Nile River respectively. Also the differences in shores width, shores inclinations and banks soils as specified in the previous chapters will affect the methods of stabilising each river banks.

6:1:1:2 Flooding

Flooding is the second variable of the Environmental Indicators. This variable describes the flood in flood season for each Nile River and the impact of this characteristic on the methods of stabilisation banks. Blue Nile as discussed is a main driving force, where the river at Khartoum

changes its direction three times from South to North, East to West and South to North. The Blue Nile carries a lot of sedimentations in flood season that caused large floodplain areas due to the erosion and sedimentation system of the alluvial meandering river. This sedimentation and erosion system caused a lot of risks to population and their properties resultant from flooding and eroding that is occurred in flood season. Part of floodplain areas are covered by water during flood season for few days when the water level is above 380.88 m above sea level, while others are not covered, but these areas are not developed due to the risk of floods.

Most of floodplain areas are private lands owned by local population. These lands are utilized in traditional agriculture or light industry for producing red mud bricks that caused pollution from CO2 resultant from burning bricks by local wood to the Nile River. This situation required certain legislations to direct the development for these lands. Therefore river banks should be stabilized so as development can take place safely. The total floodplain areas due to the study of the UNESCO Chair in Water Resources in Sudan (August 2002) are about 410 acres on the Blue Nile, 1493 acres on the White Nile due to its wide shores, 420 acres on the Main Nile and 720 acres on the confluences at Tuti Island. Flood has a significance role on type and method of stabilizing Nile River Banks due to the sedimentation materials carried by the Blue Nile in flood season. Therefore adequate and scientific study for flood and its impact on river stabilization methods should be considered in the development plan for the Nile River Front in Greater Khartoum.

6:1:1:3 Mudslides

Mudslides are the third variable of the Environmental Indicators. This variable describes the mudslides in dry season for each Nile River and the impact of this characteristic on the methods of stabilization banks. Mudslides are mainly occurred on the Blue and Main Nile River due to their natural characteristics and their bank soils. There are two main sorts of mudslides the first is the failure as beams and the second is the sliding failure. In the failure as beams water demolishes sandy layer below compacted clay loam soil that lead upper compacted clay soil suspended as cantilever beam then total or partial failure occurs on the river. This situation leads to special consideration that should be taken for the river protection banks by using appropriate retaining walls constructed from sustainable permanent materials starting from stable soil below

sandy layer soil and up to the compacted clay soil on the top of the banks soils. Sliding failure occurs mainly slowly when water level attends to decrease after flood season it demolishes part of the weak bank soils to the river stream. This situation leads to affect methods of stabilization banks.

6:1:1:4 Erosions

Erosion is the fourth variable of the Environmental Indicators. This variable describes the erosions in flood season for each Nile River and the impact of this characteristic on the methods of stabilisation banks. Erosion occurs in flood season on the Blue and Main Nile River where the White Nile is stable within the whole year. The erosion takes place due to the relative shift of the Blue Nile to the left before Burri Bridge that leads the river eroding the right banks at Khartoum North and causing sedimentation on the left banks at Khartoum. The right branch of the Blue Nile is eroding Khartoum North and causing sedimentation due to its shifting right at Sbabi. The left branch of the Blue Nile has relative shift to the right after it confluences with the White Nile that is leads to erode the left side of Tuti Island (Shore 10) and causes sedimentation at the confluences of the Blue and White Nile River forming Small Island called Wad-Dkeen which is covered by water during the whole flood season.
This situation of erosion driving forces of the Blue Nile should be considered in the methods of stabilizing river banks. The erosion sides of the river are of steep cliff or bank and with high inclination that is required appropriate study for these eroded banks so as to apply suitable sustainable method for stabilising them.

6:1:1:5 Infrastructures

Infrastructures are the fifth variable of the Environmental Indicators. This variable describes the impact of infrastructures on the methods of stabilisation banks since most of the Nile River Shores are without sustainable infrastructure.

The total length of the protected banks is only 6.5 km and the total length of the non protective banks is 61.375 km. The total length of Asphalt Street along Nile River is 14.75 km from the

total length of the river shore which is 67.875 km in our study area in Greater Khartoum. Most of these shores are without Asphalt Street, electricity, telecommunication systems and pure water. This situation because most of these shores are without stabilization banks and hence there are no sustainable developments that can take place along these unsecured shores. Therefore these shores banks must be stabilized and adequate infrastructures should be established so as sustainable development can take place on those stabilizing Nile River Front at Greater Khartoum safely.

6:1:2 Economic Factors

Economic Factors is the second type in the Main Factors Affecting Protection of the Nile River Banks which composed of three variables that specified the problems and their impact on river stabilization banks as specified below:

6:1:2:1 Economic Situations

Economic situations are the first variable in the Economic Factors type. This variable describes the general Sudan economic situations and its impact on the methods of stabilization banks. Sudan is poor and weak as it is one of the poorest countries in the world related to both regional and international standards in spite of the high natural and human resources as a resultant of the civil wars in East, South and Darfur. Now there is a little better progress in the economic situation due to the Comprehensive Peace Agreement CPA in 2005, East Peace Agreement in 2006 and Darfur Peace Agreement in 2006, but civil war in Darfur in not stopped yet that leads to slow progress in the economic on the ground.

Generally there are a progress in the economics of Sudan from 2005 to 2008 due to peace agreements, increase in petroleum production and its rates, increase in agriculture crops rates and increase in foreign direct investments. This progress leads to rapid economic development in the construction and contractor sectors which connected directly with the lands development particularly for those valuable lands along the Nile River Front. This rapid economical development for the lands on the Nile River Front is noticeable from those local, governmental

or foreign companies now start developing some of the river shores. These companies such as SUNUT Company now working in the large development project on Shore 7 as a new CBD area for Africa, United Arab Emirate now working for large recreational development area on Shore 8 and there is a governmental works for recreational purposes on shore 1 and Shore 9. This situation of rapid economic development required proper sustainable comprehensive development plan and guidelines to satisfy the following requirements:

(i) Directing and controlling the development for the whole shores.
(ii) Proper stipulated legislations managing and controlling the development.
(iii) Nile River Laws and penalties.
(iv) Building regulations for the Nile River development.
(v) Monitoring for the various types of development along Nile River.
(vi) Environmental Impact Assessment for the various developments that will be implemented on Nile River.

6:1:2:2 Landownership

Landownership is the second variable in the Economic Factors. This variable describes the situation of the landownership in study area. Most of the lands along the Nile River are governmental lands except part of the floodplain areas that used by local population in traditional agriculture and industry of red mud bricks. These private lands along Nile River are located at Tuti Island lands, part of Sbabi lands on Shore 6 and part of Ftihab lands at Shore 8. The other floodplain lands utilized by local population or not utilized yet are governmental lands. So, most of the sixteenth shores in Greater Khartoum are governmental owner lands. Even private lands could be withdrawn by the government after suitable compensation to their owners for any public development purpose due to local Compensation law.

6:1:2:3 Local Materials

Local Materials is the third variable in the Economic Factors. This variable describes the affects of local materials on the construction methods of stabilization banks. It is more economical to

use local materials in the implementation and construction of the sustainable development elements. Most of construction materials found locally in Sudan such as cement factories, steel factories, timber factories, concrete mixtures, workshops and various construction factories particularly within the last five years due to the rapid economical development that occur in the country. But some of these local building materials are not sufficient or enough to satisfy local consumptions and needs, such as the cement where the total production now as specified in the Ministry of Trade and Commerce in Sudan report (June 2008) is about one Million tons/ year while the total consumption is about 4 Million tons/ year. But now there are three large cement factories under construction in Sudan where they will start their production in the next year 2009 with total production of 4 Million tons/ year that will satisfy local consumption and the extra will be exported to African Countries.

Sudan is a potential country and rapid developments taken by local and international investors is very clearly now seen in Sudan. This situation require proper national and local plan strategy to control and direct the rapid economic development in Sudan particularly for those sorts of developments that will be implemented at the Nile River Front in Greater Khartoum.

6:1:3 Social Factors

Social Factors is the third type in the Main Factors Affecting Protection of the Nile River Banks which composed of two variables that specified the problems as specified below:

6:1:3:1 Legislations

Legislations are the first variable in the Social Factors. This variable describes the essential legislations that should be stipulated for any sustainable development that will be applied to the Nile River. There are bad utilizations and uses for the Nile River shores at greater Khartoum such as local industry for red mud bricks, local mining for lime stones and traditional agriculture. These bad uses caused pollutions to the main Nile River stream that caused great risks to local population and their animals where they are drinking water directly from the river without treatments. These bad uses are occurred from lack of legislations and laws that can control and direct the development of the Nile River Fronts at Greater Khartoum. Therefore local legislations

and regulations should be established and stipulated to direct and control the development along the Nile River Shores and these such as:

(i) Laws for Main Stream of the Nile River that able to direct and control the development and types of activities in the main river stream.
(ii) Laws for River Shores of the Nile River that able to direct and control the development and various activities applied to the river shores.
(iii) Laws for River Front of the Nile River that able to direct and control the development, managing the skyline of the Nile River, limitation of building height and building regulation or legislations for the Nile River Front in Greater Khartoum.

6:1:3:2 Local Skills

Local skills are the second variable in the Social Factors. This variable describes the affect of local skills to the method of the river stabilization banks because some methods required high skills and professionalism in certain tasks. Most of the large developments schemes carried in Arab Countries were implemented and executed by Sudanese Pioneers and skills under their direct responsibilities or share with others skills from the whole world. Therefore Sudanese people have good experience and skills in various sectors or fields of developments and they can lead any sustainable development projects that will be carried or implemented in Sudan shared with other international skills.

Fortunately now most of these Sudanese skills are emigrated from Sudan due to the bad economical and political situations and the civil wars in South and Darfur. But now due to the little progress in the economical and political situation some of these refugees whom gain high and special skills can return to their home country leading and contributing in any sustainable development that will be carried on the Nile River Front in Greater Khartoum. Other professional and skills can be imported from other countries to implement any sustainable development that will be on the Nile River Shores.

6:2 Protected Shores of the Nile River in Greater Khartoum

The protected Shores in the study area are, 3, 7 and part of Shore 9. The total length of the protected banks is 6.500 km from 67.875 km of the total length of the 16 Shores in the study area. The characteristics and specifications of these protected Shores are specified in below section.

6:2:1 Shore 3

This shore extended from Mak Nimir Bridge to the Old White Nile Dridge facing Khartoum with total length of 4000 m. The Shore Banks is stabilized with bricks and masonry walls. Most of the urban elements in Greater Khartoum such as Khartoum CBD area, recreational areas, public parks, cultural areas, amenities, tourist areas, governmental areas, Khartoum Football Stadium, main cars parking areas and most of the important governmental buildings are located on this Shore. Therefore this Shore is considered one of the most potential Shores in Greater Khartoum.

6:2:2 Shore 7

This shore extended from Old White Nile Bridge to Engaze Bridge facing Khartoum with total length of 1250 m. The shore protected by Dry Pitching on Earth Embankments where new CBD area for Africa will be located on this shore with total area as specified before of 145 acres.

6:2:3 Shore 9

This shore extended from Old White Nile Bridge to Shambat Bridge facing Omdurman with total length of 3750 m. The stabilized part from this shore is stabilized from masonry walls with total length of 1250 m. Most of Omdurman recreational areas are located on this protected part of Shore 9. The remaining part of this Shore with total length of 2500 m is without stabilization banks.

The below sections will consider the methods of stabilization banks for each Nile River Shores in Greater Khartoum.

6:3 Methods of Stabilization Banks for each of the Blue Nile Shores

Blue Nile is a main driving force for any methods of stabilizing Nile River Banks due to its natural characteristics and distinctive factors that affecting the main pattern of the Nile River system as specified in the previous chapters. The characteristics of the Blue Nile Shores are varies where some of them due to the sedimentation system of the river are containing large floodplain areas while others due to the erosion system have steep inclination banks and without floodplain area. The variation in water level may be reached 7.82 m between flood and recession period as illustrated in the below Fig 6-1 and details of the right and left bank of the Blue Nile in Fig 6-2 and Fig 6-3.

Fig 6-1 Cross Section $X_1 - X_1$ on the Blue Nile (source the author)

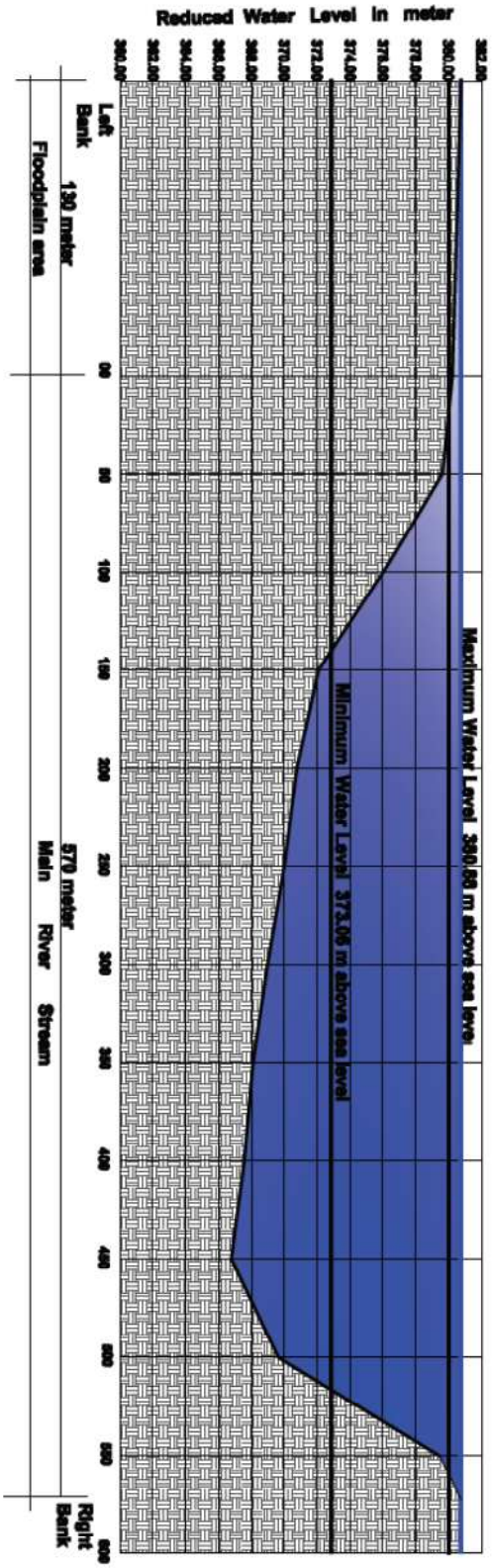


Fig 6-2 Right Bank of the Blue Nile (source the author)

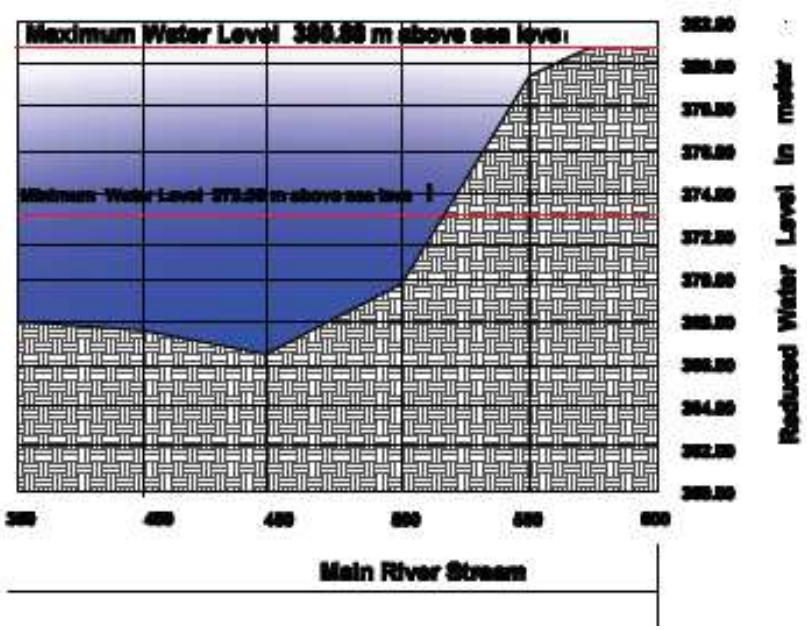
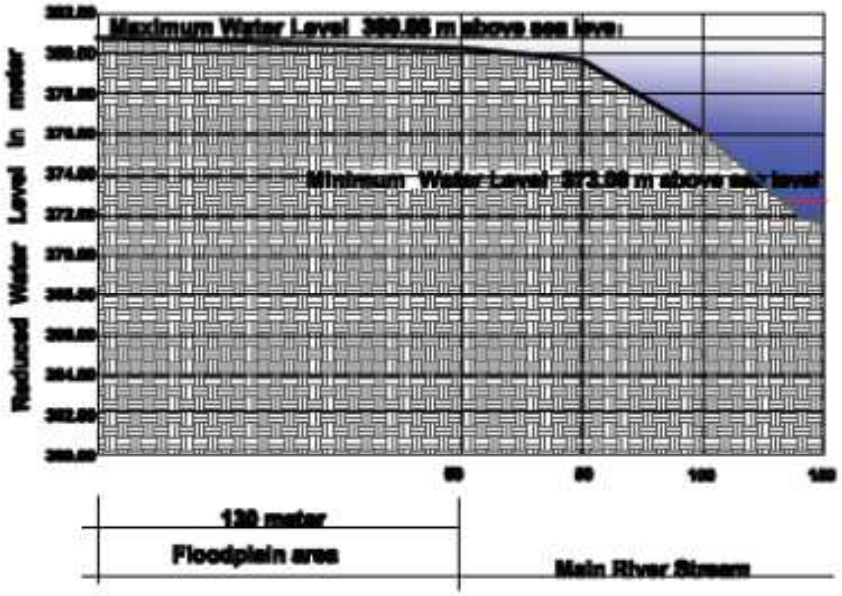


Fig 6-3 Left Bank of the Blue Nile (source the author)



The above figures; Fig 6-1, Fig 6-2 and Fig 6-3 illustrate that; the right bank is affected by the active erosion during flood period and the left bank is affected by sedimentation system that makes large floodplain area.

The soil classification banks are varies between the left and right bank due to the Blue Nile pattern system which has direct impact on the methods and types of river protection banks for each shore. These soil classifications for the Main Blue Nile, Left Blue Nile Branch and Right Blue Nile Branch in the study of the UNESCO Chair in Water Resources in Sudan Carried in (August 2002 p.39 v. 5) are as specified in Table 6-1.

Table 6-1 Soil Classifications of the Blue Nile Banks

River Reach	**Zone of Cross Section**	**Left Bank**				**Right Bank**			
		Composition %			**Classification**	**Composition %**			Classification
		Clay	**Silt**	**Sand**		**Clay**	**Silt**	**Sand**	
Blue Nile Main Channel	1	33	28.5	38.5	Sandy Clay	36	34	30	Clay
	2	37	40	23	Silt Clay	35	39	26	Clay
	6	25	23	52	Sandy Clay Loam	35.5	31.5	33	Clay
Blue Nile Left Branch	3	36	30	34	Clay	37	30	33	Clay
Blue Nile Right Branch	17	26	26	48	Clay Loam	30	30	40	Clay Loam
	19	37.5	37	25.5	Clay	27.5	26.5	46	Sandy Clay Loam

Table 6-1 illustrates the variations of the bank soil classifications between left and right bank soils of the Blue Nile banks as indication of the variation of the Blue Nile Banks soils. Therefore the suitable methods of stabilizing Blue Nile Banks are varies due to the different characteristics and variable forces of each one of them as specified below for the different Blue Nile Shores.

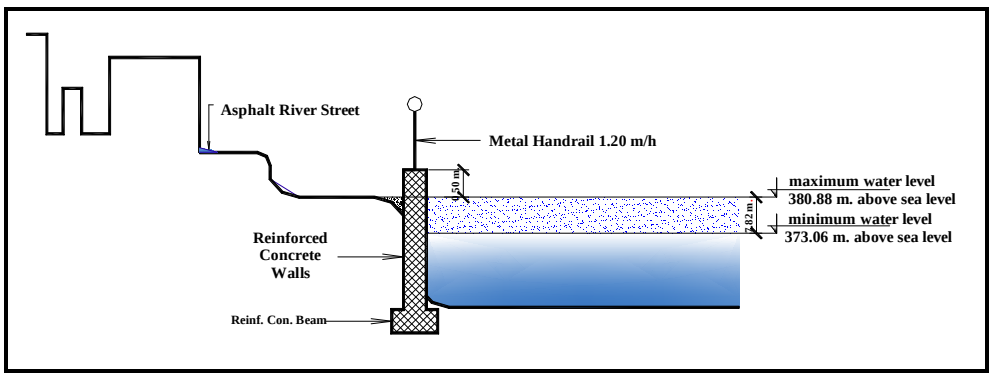
6:3:1 Shore 1

This shore as specified before extended from Burri Bridge to Mank Nimir Bridge facing Khartoum with total length of 3000 m without stabilization banks and part of it is containing floodplain area of about 40 acres. The shore is potential, accessible, near the CBD area of Khartoum, located on the sedimentation side of the river and from the study of the cross section X1 - X 1 and those specified in Appendix 1, the suitable methods for stabilizing this shore composed of two methods of stabilization banks as specified below:

6:3:1:1 Concrete Walls Method

This method will be applied to the first part of the shore bank extended from Mak Nimir Bridge to the Blue Nile River Sport Club with total length of 500 m. Concrete Walls for bank stabilization method composed of reinforced concrete walls starting from the lower part of the stable bank soil which will be determined by engineers due to soil investigations, soil tests, pattern flow system, structural methods, various driving forces and river simulation for the Blue Nile River up to the upper part of the bank. The upper level of the bank is determined according to the variation level between maximum and minimum water level in flood and dry period (380.88m and 373.06 m) above sea level as specified before in Blue Nile Data Table 3-1 for (50 years) by MIS which is 7.82 m. Then if we add 50 cm above maximum water level for waves and construction of handrails, so the top level of the concrete walls will be 381.38 m above sea level and the total height of the concrete walls will be 8.32 m (7.82 + 0.50 = 8.32 m) as illustrates in Fig 6-4.

Fig 6-4 Concrete Walls Method (Source the Author)



The suitability of Concrete Walls method for this 500 m on this shore for the following justifications:

(i) High cliff of the river bank.

(ii) To locate on it Main River Station for the new methods of river transportations.

(iii) The Location of the River sport Club will be on this part of the concrete walls.

(iv) There is no floodplain at this part of the shore.

(v) This part is a nearest part to the CBD area at Khartoum.

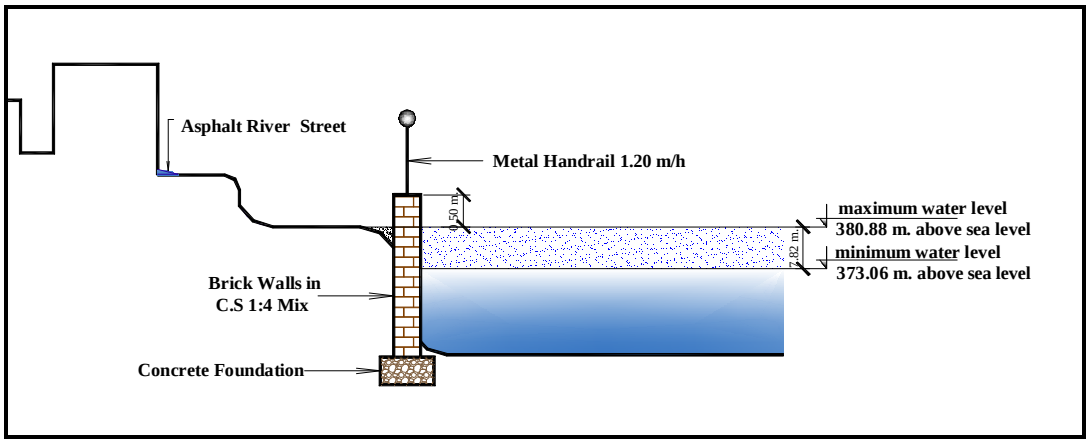
(vi) To locate on it new station for recreational and water based activities.

(vii) To act as one of the main points in the Greenway System that will be applied at Greater Khartoum.

6:3:1:2 Concrete and Brick Walls Method

This method will be applied to the rest of the shore that extended from the Blue Nile River Sport Club to Burri Bridge with total length of 2500 m. Concrete and Brick Walls Method composed of reinforced concrete foundation starting from the stable soil of the lower river bank that is determined according to engineering works. Then brick or stone walls in cement sand mortar laid on reinforced concrete foundation up to the level of the above concrete walls 381.38 m above sea level. The total height of the wall from the lower bottom of the bank to the up level is 8.32 m (7.82 +0.5 = 8.32 m). Handrail from steel similar to that in the first part will be applied and constructed on brick walls as illustrates in Fig 6-5.

Fig 6-5 Concrete and Brick Walls Method (Source the Author)



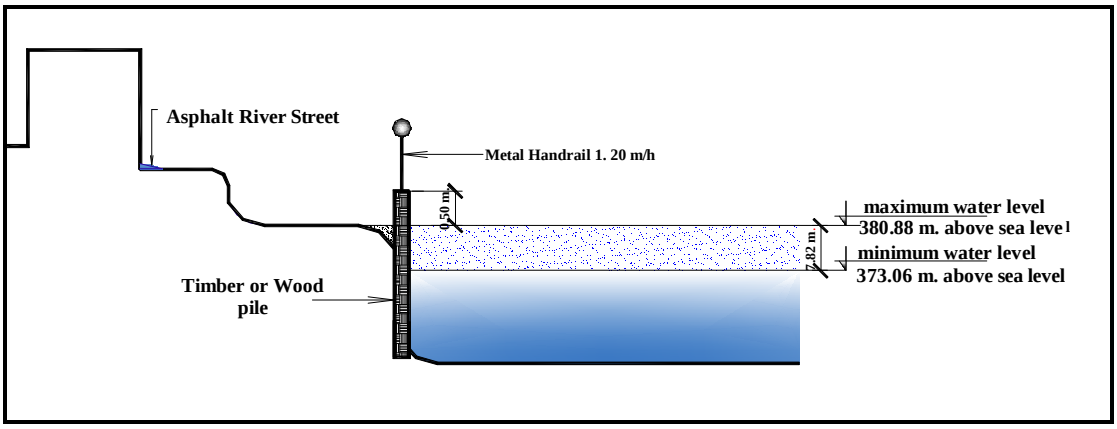
6:3:2 Shore 2

This shore facing Khartoum North extended from Burri Bridge to Mak Nimir Bridge with total length of 3000 m without floodplain and facing the erosion side of the Blue Nile. Part of this shore is without accessibility to the river due to the military area along it with total length of 1700 m. The cliff of the bank along this shore is steep with high inclination due the erosion system of the Blue Nile. Therefore a simple method of stabilization banks can be applied to this part is Timber or Wood piling Method.

6:3:2:1 Timber or Wood piling Method

This method of stabilization banks starting from the lower bottom of the bank up to the upper part of the bank with 50 cm extra for waves and construction of handrails with total height of 8.32 m as specified in Shore 1 and illustrates in Fig 6-6. The accessible part of the shore which is 1300 m will be stabilized by Concrete Walls Method for the River Stop Station No 19 with total length of 100 m and the remaining part which is 1200 m will be stabilized by Concrete and Brick Walls Method.

Fig 6-6 Timber or Wood Pilling Method (Source the Author)



6:3:3 Shore 3

This shore extended from Mak Nimir Bridge to the Old White Nile Dridge facing Khartoum with total length of 4000 m and with stabilization bank from masonry walls. Most of the urban elements such as Khartoum CBD area, recreational areas, public parks, cultural areas, amenities, tourist areas, governmental areas, Khartoum Football Stadium, main cars parking areas and most of the important governmental buildings are located along it. Therefore another river station or harbour for river transportation methods will be located on this important shore. The suitable location for this river station or river harbour is at Friendship Hall with total length of 200 m as River Stop Station No 2 and constructed from Concrete Walls Method. This station can offer services to different Nile Cruises, river sports, river transportation methods, water base recreation and to be one of the main point of the Greenway System that will be applied in this study.

6:3:4 Shore 6

This shore is extended from Mak Nimir Bridge to Shambat Bridge at the confluence point of the Right Branch of the Blue Nile facing Khartoum North with the Main Nile. The total length of this shore is 4250 m and containing floodplain area of about 100 acres. From previous information such as soil classifications in Table 6-1, cross section X1 -X1, the characteristic of this shore in previous chapters, the Khartoum North CBD area near this shore and the need for River Stop Station No 4, therefore suitable methods for stabilizing banks of this shore will be as specified below:

6:3:4:1 Concrete Walls Method

This method is applied for only 100 m at the Friend Ship Hotel to cater for the River Stop Station No 4 to serve the various river activities and any recruitment for future development. The specification of this method is illustrates in Fig 6-4 above.

6:3:4:2 Concrete and Brick Walls Method

This method of stabilization banks is suitable for the remaining part of the bank which is 4150 m long. The specification of the construction materials for this method is illustrates in Fig 6-5.

6:3:5 Shore 13

This shore is extended from Burri Bridge to Manshia Bridge on the Blue Nile facing Khartoum with total length of 4500 m and contains large floodplain area of about 150 acres. Methods of stabilizing banks of this shore will be affected by the following factors:

(i) The river sedimentation system.
(ii) The engineering works specified in the cross sections in Appendix 1.
(iii) The potentialities of the shore where it is facing first class residential areas without recreational areas such as Garden City, Manshia and Riade.
(iv) It is containing large floodplain area of about 150 acres.
(v) Location of two Stations required to work within the river transportation system.
(vi) Contribution of the Greenway System that will be applied to Greater Khartoum.
(vii) Consideration of the previous data about this shore for sustainable development.

Taking consideration for above factors, the suitable methods for stabilizing this shore banks is the method of Concrete and Brick Walls as illustrates in Fig 6-5 above with total length of 4200 m. The shore faces first class buildings and villas at Greater Khartoum therefore, two stations for river stops will be located on it. The first station on this shore which is River Stop Station No 5 will be located at Garden City with total length of 100 m and will be stabilized by Concrete Walls Method. The second station which Sub Main Station No 6 and it will be located at Manshia Bridge with total length of 200 m and stabilized with Concrete Walls Method.

6:3:6 Shore 14

This shore is extended from Burri Bridg to Manshia Bridge on the Blue Nile facing Khartoum North with total length of 4500 m and containing floodplain area of about 200 acres. The Blue Nile shifting to the left that causes sedimentation on the right side and erosion on this left side. The length of floodplain on this shore is 2500 m and the eroded part is 2000 m facing military area. There is a requirement for two River Stop Stations No7&8, which can be located at Manshia Bridge to serve river activities and future development of the riverfront at Greater Khartoum with total length of 100 m for each station. Therefore according to those requirements

and from previous information about this shore the suitable methods for stabilizing banks of this shore are:

6:3:6:1 Concrete Walls Method

This method is suitable for the River Stop Station No 7 & 8 with total length of 200 m (100 m for each station). The specification of this method is illustrates in Fig 6-4.

6:3:6:2 Concrete and Brick Walls Method

This method is suitable for the part of the shore extended from Burri Bridge with total length of 2300 m where there is large floodplain area. The specification of this method of stabilization banks is illustrates in Fig 6-5.

6:3:6:3 Timber or Wood piling Method

This method is suitable for stabilizing the remaining erosion part of this shore bank which is 2000 m for the following reasons:

(i) It is not accessible for it facing military areas.
(ii) It is of low value eroded land.
(iii) There is no river stop station because it is not accessible.
(iv) This part is not potential due to the military areas.

Summary of the proposed methods for stabilizing banks of the Blue Nile Shores is specified in Table 6-2

Table 6-2 Length and proposed Methods of Stabilizing Blue Nile Shores

Shore No	Shore Length in m	Length (in m) and proposed types of Stabilization Methods			
		Concrete Walls	Concrete and Brick Walls	Bricks or \ and Masonry Walls	Timber Wood Pilling
1	3000	500	2500		
2	3000	100	1200		1700
3	4000	200		3800 (existing)	
6	4250	100	4150		
13	4500	300	4200		
14	4500	200	2300		2000
Total	23250	1400	14350	3800	3700

Table 6-2 illustrates that, the protected bank is represented only 18% from the total length of the Blue Nile Shores, concrete walls method will be applied for the river stop stations and most of the remaining banks will be protected with concrete and or/ masonry walls method.

6:4 Methods of Stabilization Banks for each of the White Nile Shores

White Nile as specified before has wide shore with slow inclination due to its stable discharge flow which is 73 Million m^3/ day as specified before within the whole year. The maximum and minimum water level between flood and dry season are 380.66 and 373.21 m above sea level as specified before in the UNESCO Chairs study (August 2002) and as illustrated in Fig 6-7 and details of the right and left bank.

Fig 6-7 Cross Section $X_2 – X_2$ on the White Nile (source the author)

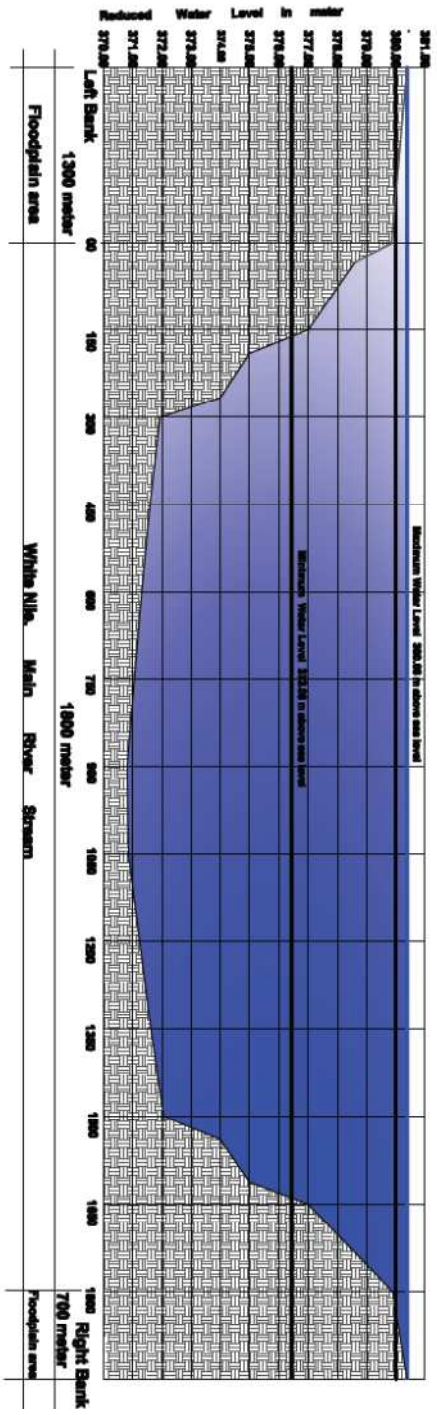


Fig 6-8 Right Bank of the White Nile (source the author)

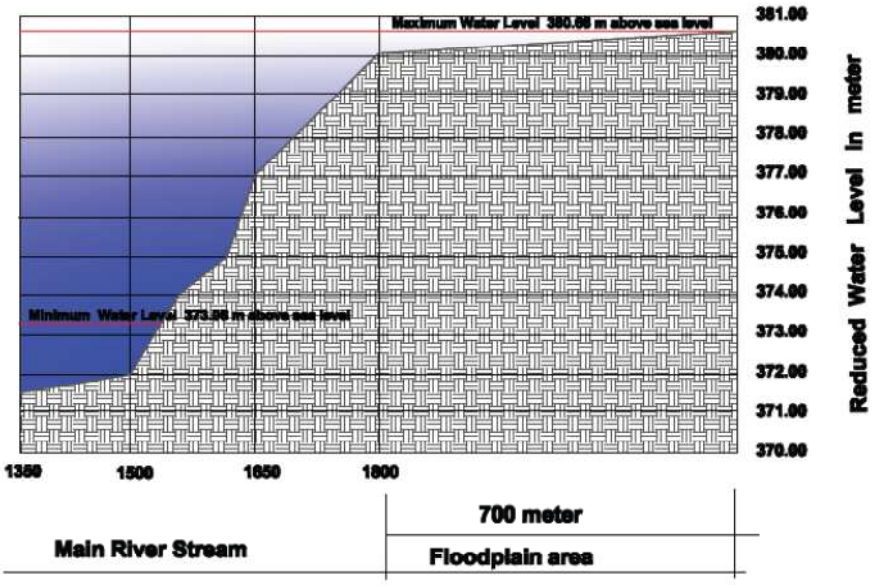
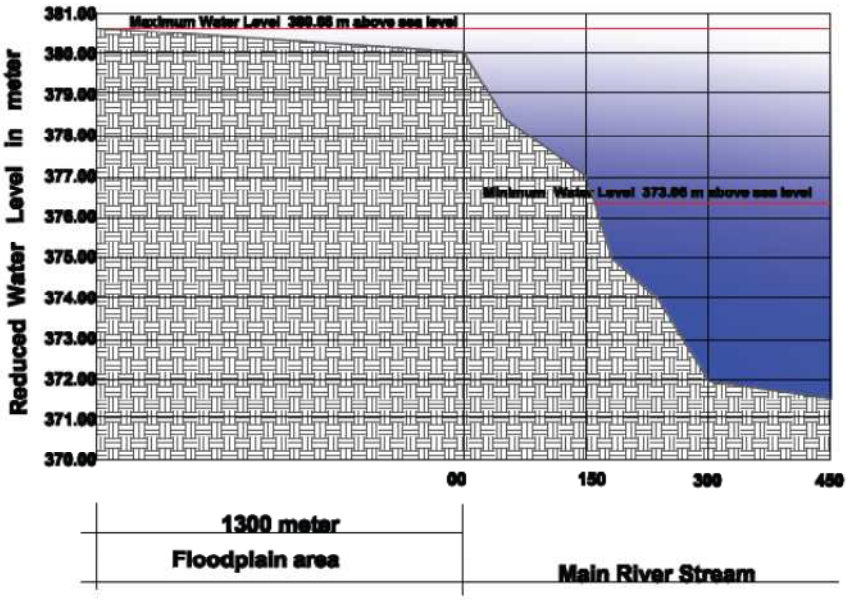


Fig 6-9 Left Bank of the White Nile (source the author)



The above figures; Fig 6-7, Fig 6-8 and Fig 6-9 illustrate that; the left and right bank are of wide shore due to the stable discharge and hydrology of the White Nile River.

The bank soil classifications for the White Nile in the study of the UNESCO Chair in Water Resources is as specified in below Table 6-3

Table 6-3 Bank Soil Classification source UNESCO Chair in Water Resources-study for Khartoum CBD study team (August, 2002 v. 5 p. 39)

River Reach	Zone	Left Bank				Right Bank			
		Composition %			Classification	Composition %			Classification
		Clay	Silt	Sand		Clay	Silt	Sand	
White Nile	1	42	38	20	Clay	43	39.5	17.5	Clay
	14	30	27.5	42.5	Clay	18	10.5	67.5	Sandy Loam

White Nile is of stable flow discharge as specified before. Therefore a method of stabilizing banks can be one method that is, Masonry on Dry Pitching Earth Embankments Method, but for the purpose of this study and to satisfy the requirements of sustainable development the study will illustrate the suitable methods for each shore as specified below.

6:4:1 Shore 7

This shore extended from Old White Nile Bridge to Engaze Bridge facing Khartoum with total length of 1250 m. The shore protected by Dry Pitching on Earth Embankments where new CBD area for Africa will be located on this shore with total area as specified before of 145 acres.

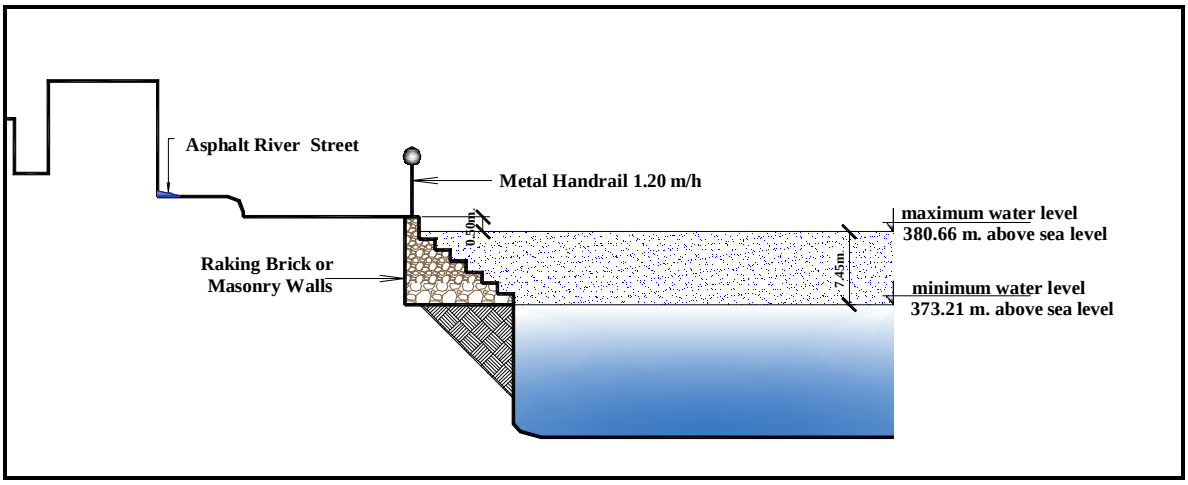
6:4:2 Shore 8

This shore extended from Old Omdurman Bridge to Engaze Bridge facing Omdurman with total length of 1250 m. The difference between flood and dry season levels is 7.45 m and if we add 50 cm for handrails and wave the total stabilization height from bottom level will be 7.95 m. Therefore any sustainable stabilization method for White Nile Banks should not be less than level 381.16 m above sea level. The suitable method for stabilizing this shore bank is as specified below.

6:4:2:1 Raking Brick and/ or Masonry Walls Method

From previous information the level of stabilization bank should be up to the level 381.16 m above sea level with total height of 7.45 +0.5=7.95 m. The shore contains floodplain area of about 88 acres that can be developed for recreational and various development elements. This method due to the low inclination of the bank can be constructed in steps or racking way as illustrates in Fig 6-10.

Fig 6-10 Raking Brick and / or Masonry Walls Method (Source the Author)



6:4:3 Shore 15

This shore extended from Engaze Bridge to Salha Bridge facing Khartoum with total length of 11000 m. This shore is facing high density residential areas and Sunut Natural Forest as conservation area of about 360 acres. This forest is the only natural forest in Greater Khartoum that can be developed to act as the main recreational area for the population and improve the environment. There is a need for three river stations to be located on this long shore and from these and previous information the suitable methods for stabilizing banks of this shore are:

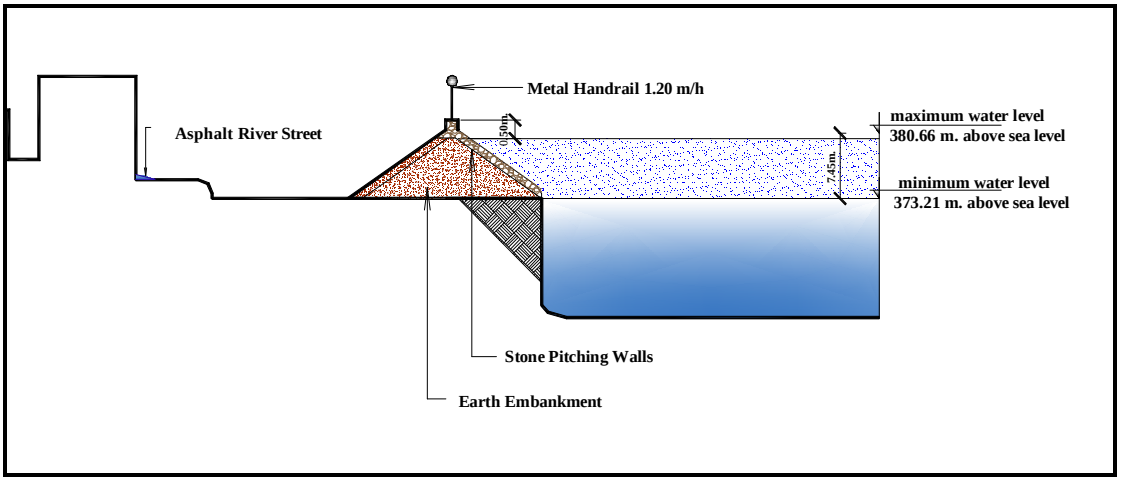
6:4:3:1 Raking Brick and /or Masonry Walls Method

This method is suitable for the three river stations which are River Stop Station No 10 at Engaze Bridge facing Sunut Natural Forest with total length of 100 m, River Stop Station No11 at Shagra Residential area with total length of 100 m and Sub Main River Station No 12 at Salha Bridge with total length of 200 m. The specification of this method of stabilization banks is illustrates in Fig 6- 10.

6:4:3:2 Masonry on Dry Pitching Earth Embankments

This method is suitable for stabilizing the remaining banks of this shore with total length of 10600 m. This method due to the slow inclination of the White Nile Shore composed of compacted dry pitching earth embankments up to level 381.16 m above sea level and this earth embankments covered by pitching stones in cement sand mortar. The stones layers protect the compacted earth embankments from being demolished by river water and waves particularly in flood season. The construction of this method of stabilization bank is illustrates in Fig 6-11.

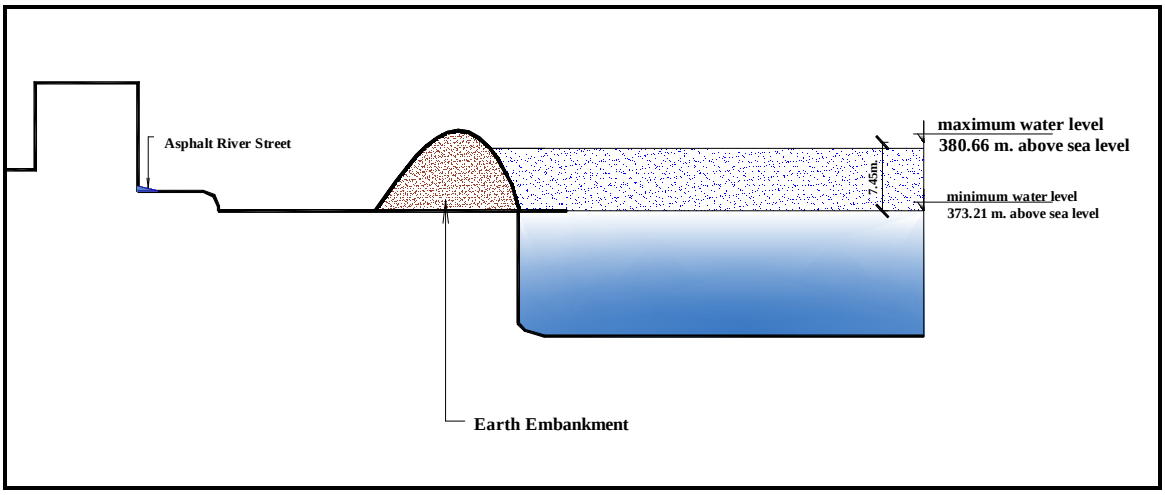
Fig 6-11 Masonry on Dry Pitching Earth Embankments (Source the Author)



6:4:4 Shore 16

This shore extended from Engaze Bridge to Salha Bridge facing Omdurman with total length of 11000 m. The first part of it is facing urban area while the remaining part is facing rural poor areas. The urban residential areas extended from Engaze Bridge up to 2000 m from the bridge and it is near the shore while the remaining part of the shore which is 9000 m facing rural areas far from the shore. The shore contains large area covered by the river in flood season which is about 900 acres used for agriculture by local rural population. The suitable stabilization method for the urban part which is 2000 m is the Raking Brick and/ or Masonry Walls Method, with Sub River Stop Station No 9 at Engaze Bridge. The part facing rural areas will be stabilized by Raking Masonry Walls Method for River Stop Station No 13 at Salha Bridge with total length of 100 m and the remaining part which is 8900 m will be stabilized with compacted earth embankments as illustrates in Fig 6-12.

Fig 6-12 Compacted Earth Embankments (Source the Author)



6:5 Methods of Stabilization Banks for each of the Main Nile Shores

The Main Nile River as specified before is of similar characteristics to the Blue Nile. The discharge flow of the Main Nile is equal to the total discharge flow of the White and Blue Nile. The maximum and minimum water level in flood and dry season are 376.88 m and 368.82 m above sea level respectively with variation level of 8.06 m as illustrated in Fig 6-13 to Fig 6-15.

Fig 6-13 Cross Section $X_3 – X_3$ on the Main Nile (source the author)

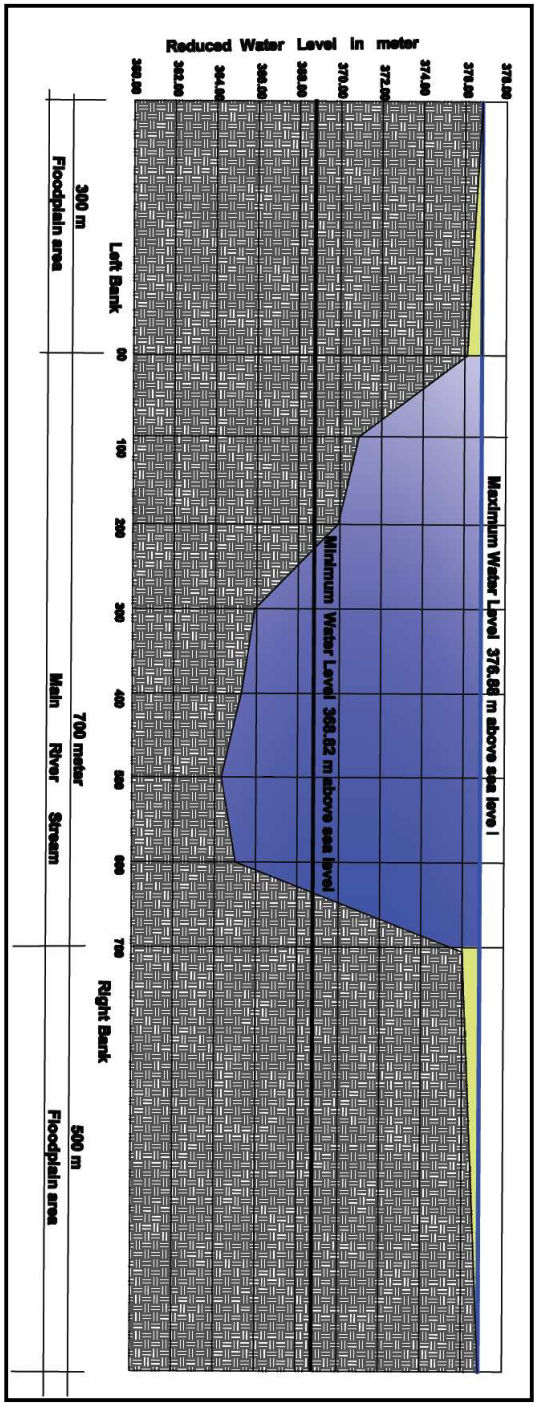


Fig 6-14 Right Bank of the Main Nile (source the author)

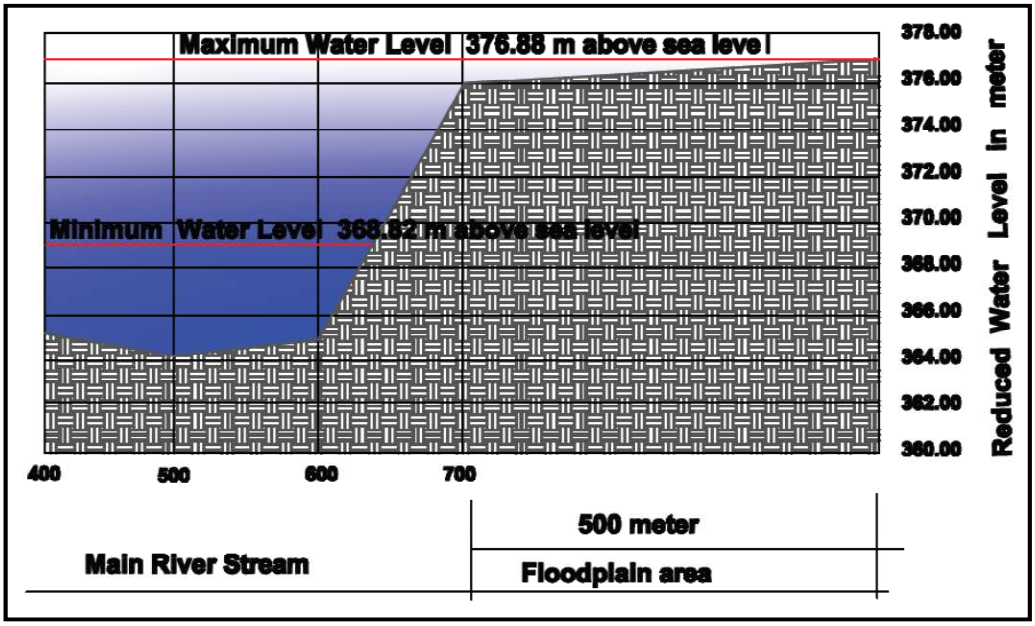
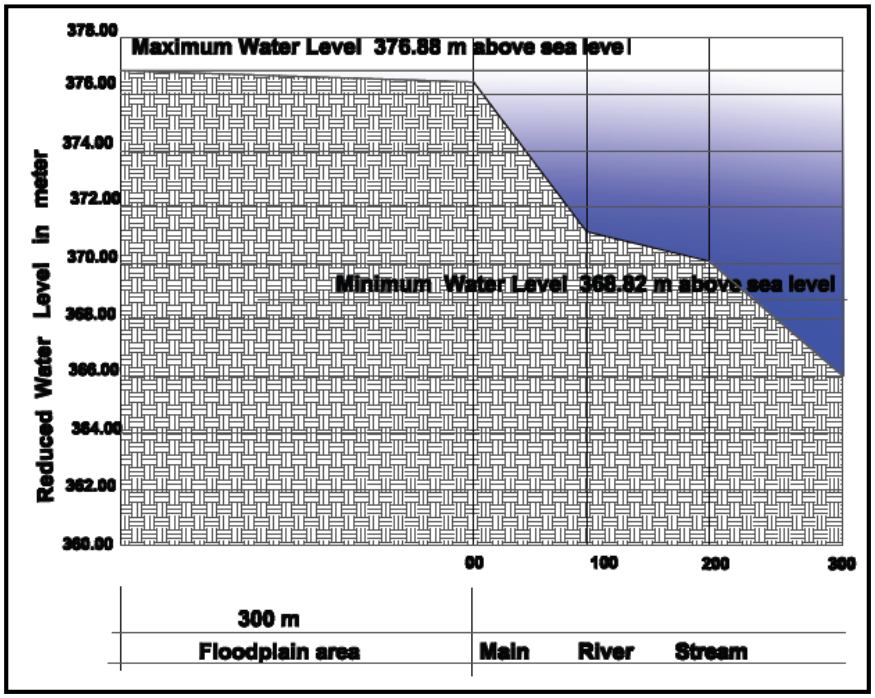


Fig 6-15 Right Bank of the Main Nile (source the author)



The above figures; Fig 6-13, Fig 6-14 and Fig 6-15 illustrate that; the right and left banks are affected by the river pattern system where there are sedimentation that occurred on the large floodplain area on both sides of the river.

The variation level as specified before is 8.06 m and if we add 50 cm for waves and handrails construction the total height of stabilizing walls will be 8.06+0.5= 8.56 m. Therefore any method for sustainable stabilization banks for the Main Nile should not be less than level 377.38 m above sea level. Methods of stabilizing Main Nile Banks are different due to characteristics, potentialities, lands ownerships, river pattern, river stations, bank soils and previous information about hydrology and morphology of the river. The suitable methods for stabilizing each shore are as specified below:

6:5:1 Shore 9

This shore extended from Old White Nile Bridge to Shambat Bridge facing Omdurman with total length of 3750 m. Most of Omdurman recreational areas are located on this shore. Part of this shore is with stabilization bank of a length of 1250 m, while the remaining part which is 2500 m is without stabilization. Due to the characteristics, potentialities and need for river stop stations, the suitable methods for stabilizing the remaining part of this bank are:

6:5:1:1 Concrete Walls Method

This method is suitable for the River Stop Station No 14 with total length of 100 m. The suitable location of this river stop station is Almorada.

6:5:1:2 Concrete and Brick Walls Method

This method is suitable for the remaining part of the shore with total length of 2400 m.

6:5:2 Shore 11

This shore extended from Shambat Bridge to University of Khartoum College of Agriculture facing Khartoum North with total length of 3000 m. The shore has floodplain area of about 200 acres. The shore will be stabilized by Concrete and Brick Walls Method at the old flood plain

area and to let the new one for agriculture with total length of 2900 m. River Stop Station No 16 is required to be located at Shambat Bridge with total length of 100 m and to be stabilized by Concrete Walls Method.

6:5:3 Shore 12

This shore extended from Shambat Bridge to Khor- Elnaim facing Omdurman with total length of 3000 m. The shore has floodplain area of about 70 acres used in agriculture and local industry of mud bricks that caused pollution to this area. Old Omdurman residential areas like Aboroof, Bait- almal and Kabajab are located on it and closed to the river shore. The soil bank is stable and there are no recreational areas on this shore. Therefore suitable method of stabilizing this shore will be similar to Shore 11, which are 2900 m by Concrete and Brick Walls Method and 100 m by Concrete Walls Method for River Stop Station No15 that located at Shambat Bridge.

6:6 Methods of Stabilization Banks for each of the Confluences Shores at Tuti Island

Methods of stabilizing banks of Tuti Island at the confluences of the Blue and White Nile in the development plan for the development of the Nile River Front in Greater Khartoum will be as specified below:

6:6:1 Shore 4

This shore on the Left Branch of the Blue Nile facing Tuti Island extended from the Eastern side of the island up to the Southern side that facing Khartoum with total length of 3500 m. The shore is eroded by the Left Branch of the Blue Nile in flood season due to the relative shift of this branch to the right. Backward water from White Nile into this Left Branch is occurred in dry season due to the variation discharge flow of the White Nile and the Blue Nile in dry season as specified in previous chapters. These forces of two rivers pattern system are affected methods of stabilizing banks of this unique island. Methods of stabilizing this shore should satisfy the following requirements:

(i) The unique location of the island for future development.

(ii) The potentialities of the island specified in previous study.

(iii) The various forces of the two rivers pattern system.

(iv) The engineering works specified in cross sections X8 to X10 in Appendix 1.

(v) Location of River Stop Station No 3 and harbour for river transport and water activities.

(vi) To act as one of the main attractive points in the Greenway System in a proposed development plan.

To satisfy those requirements the suitable methods for stabilizing this shore bank by using method of Concrete Walls Method for 200 m for sub river station and the remaining part of the shore which is 3300 m to use Concrete and Brick Walls Method. The specifications of these two methods illustrate in Fig 6-4 and Fig 6-5 above respectively. The suitable location for Sub Main River Station No 3 is the existing location of 'Tuti- Panton Station' facing Friendship Hall and it will face River Stop Station No 2.

6:6:2 Shore 5

This shore on the Right Branch of the Blue Nile facing Tuti Island extended from the Eastern side of the island up to the Northern side facing Khartoum North with total length of 3875 m. The flow discharge of the Blue Nile is divided between the Right and Left Branch by the ratio 3:2 respectively as specified in the engineering study by (UNESCO Chairs, 2002). The bank of this shore is eroded by the Right Branch of the Blue Nile and referring to the cross sections X16 to X19 in Appendix 1, the suitable methods of stabilizing this bank are:

6:6:2:1 Concrete Walls Method

This method is suitable for the River Stop Station No 18 with total length of 100 m. Specification of the construction of this method is illustrates in Fig 6-4.

6:6:2:2 Concrete and Brick Walls Method

This method is suitable for the remaining part of the shore with total length of 3775 m. The specification of the construction materials for this method is illustrates in Fig 6-5.

6:6:3 Shore 10

This shore extended from Southern side to the Northern side of Tuti Island facing Omdurman with total length of 3000 m. The shore is eroded by the Nile River and from previous information the suitable method due to the potentiality of the island is similar to the method of Shore 5, which is Concrete and Brick Walls Method with total length of 2900 m as illustrates in Fig 6-5. The River Stop Station No 17 on this shore will be stabilized by Concrete Walls Method with total length of 100 m.

6:7 Summary of Chapter Six

Chapter six explored data derived from previous chapters to develop a set of guidelines for suitable methods of stabilizing Nile River Banks in Greater Khartoum as first area of this study. The chapter start with the specifications of the main factors that affecting protection of the Nile River Shores. These main factors are related to environment, economic and social issues. The chapter also specified the methods of the existing protected shores and their total length. The stabilized Shores in the study area are Shore 3, 7 and part of Shore 9 with total length of 6.500 km from 67.875 km of the total length of the 16 Shores in the study area. The chapter tackled the methods of stabilizing each of the six Blue Nile Shores. The Blue Nile Shores Banks were stabilized in the proposed development plan with concrete walls methods for the river stop stations which will be used also for water based activities that adapted to the Nile River as main Blue Way in Greater Khartoum, concrete and bricks walls method for the remaining of those shores except the Blue Nile Banks that facing the military area which stabilized with timber wood pilling. The chapter tackled methods of stabilizing the White Nile Shore Banks. The White Nile Shores due to the stable discharge are wide, therefore they were stabilized in the proposed development plan with masonry on dry pitching earth embankment method, raking bricks walls method and compacted earth embankment for that shore bank facing the rural areas in Greater Khartoum. The chapter specified methods of stabilizing each Shore of the three Main Nile Banks. They were stabilized in the proposed development plan for the Nile River Front in Greater Khartoum with concrete walls methods and concrete and bricks walls method due to the similar features of the Main Nile Shores to those of the Blue Nile Shores. Also the chapter tackled the methods of stabilizing the confluences shores at Tuti Island. The three confluences

Shores were stabilized in the proposed development plan with concrete walls method for river stop stations and concrete and bricks walls method for the remaining parts of the three shores with total length of 10.375 km.

The next chapter will tackle the Sustainable Development of the Nile River Front SDNRF in Greater Khartoum as second area of this study.

CHAPTER SEVEN: GUIDELINES FOR THE NILE RIVERFRONT DEVELOPMENT

7:0 Introduction

Chapter seven will develop a set of guidelines based on previous chapters a development plan that control and direct the development of the Nile River Shores as second area in this study. This will be gained by developing a set of sustainable indicators that measuring the suitability of the development for the Nile River Shores and proposed development plans. The sustainable indicators are mainly related to:

- Environmental Indicators which will tackle methods of stabilization banks that specified in previous chapter, traffic system, accessibility to the river, flexibility of the development, potentiality of the development that support greenway system in Greater Khartoum, sky line of riverfront, blue way of the Nile River and improvement of the general environment in Greater Khartoum.

- Economic Indicators which composed of indicators that measuring increase in land value due to the proposed development for Nile Shores, indicators that measuring a degree of changes of uses in lands due to the proposed development for Nile Shores and contributions of the development in improving local and national economy of the study area.

- Social Indicators which will tackle indicators that measuring the degree of satisfaction of population needs due to proposed development and indicators that measuring the degree of improvements in social services that that occurred from the development.

The chapter will develop a set of guidelines that measuring a degree of successful development of the Nile River Shores and information in previous chapters about SD to test and establish proposed development plan for the Nile River Front at Greater Khartoum to satisfy the sustainable indicators. The proposed development plan which will be tentatively established in this chapter will satisfy the environmental, economical and social indicators. The proposed development plans illustrated with figures will tackle the following issues:

- Proposed development plan for River Traffic System that lead to establish new urban elements and better utilization of the Nile River in Greater Khartoum. The system will

establish river stop stations that will be used in river transportation system and river water based activities.

- Proposed development plan for Grey Way System that lead to improve the general infrastructure and accessibility to Nile Shores in study area.

- Proposed development plan for cornice and Greenway System that composed of main, sub main and attractive points. This system develops a set of guidelines for developing Nile River Shores and creation of new urban elements in Greater Khartoum.

- Proposed development plan for zoning areas which lead to develop a set of guidelines that control and direct the development in the study area.

7:1 Main Indicators for Sustainable Development of the Nile Riverfront

Main Indicators that should be considered in the proposed plan for the Sustainable Development of the Nile Riverfront SDNRF at Greater Khartoum composed of environmental indicators, economic indicators and social indicators. Each one of these composed of a number of types and each type composed of a number of indicators or variables that measuring the degree of sustainability of any development that will be implemented on the Nile River Front in Greater Khartoum as specified in sections below:

7:1:1 Environmental Indicators EI

Environmental Indicators EI composed of eight types and each type composed of a number of indicators or variables that measuring the quality of that type and hence the degree of sustainability of the development that will be applied to the Nile River Front at Greater Khartoum as specified below:

7:1:1:1 Banks Stabilization Methods

Banks stabilization methods are the first type of the Environmental Indicators which composed of a number of variables that represent degree and quality of the banks stabilizations methods and hence successful sustainable development to the Nile River Font at Greater Khartoum. Methods of stabilization banks are variables and they are varying due to the sort of materials used in that method of stabilization banks as specified and illustrates in previous chapter.

7:1:1:2 Traffic Systems

River Traffic System is the second type of the Environmental Indicators which composed of a number of variables that represent degree of the quality of the traffic system and hence successful sustainable development that will be implemented to the Nile River Font. Traffic System composed of variables or indicators that used in traffic system to the Nile River Front in hierarchical way as specified below:

(i) River traffic system.
(ii) Train traffic lines adjacent to the Nile River Front.
(iii) Asphalt streets adjacent to the Nile River Front.
(iv) Earth streets adjacent to the Nile River Front.

7:1:1:3 Accessibility

Accessibility to the Nile River Front is the third type of the Environmental Indicators which composed of a number of variables or indicators that represent degree of the quality of accessibility to the Nile River and hence, successful sustainable development that implemented to the Nile River Font. Accessibility composed of variables or indicators that measuring the quality of the methods used for accessibility to the Nile River Front in hierarchical way as specified below:

(i) Accessibility to the Nile River by Nile River Transport.
(ii) Accessibility to the Nile River by Public Asphalt Street.
(iii) Accessibility to the Nile River by Public Earth Street.

(iv) Accessibility to the Nile River through public space.

(v) Accessibility to the Nile River through private space.

7:1:1:4 Flexibility

Flexibility is the fourth type of the Environmental Indicators which composed of a number of variables or indicators that represent a degree of the quality of successful sustainable development that could be implemented to the Nile River Font at Greater Khartoum. Flexibility composed of a number of variables or indicators that measuring continuation and coherence of the various elements of the sustainable development that will be applied to the Nile River Front as specified below:

(i) Continuation of the main development elements.

(ii) Coherence of the development elements.

(iii) Degree of change to better performance.

(iv) Degree of adaptation with local factors.

(v) Monitoring and management legislations.

7:1:1:5 Potentiality of the Greenway System in Greater Khartoum

Potentiality of the greenway system at Greater Khartoum is a fifth type of the Environmental Indicators. It composes of a number of variables or indicators which support the successful idea about greenway system along the Nile River Front in Greater Khartoum. The situation of Greater Khartoum will support greenway system idea, where original and destination points containing hub attractive points with links points between them, due to the various potential elements that support the idea and from which greenway system can consists as specified in below section:

(i) Main attractive points in study area and from which greenway system consists of such as Main Public Parks, Sunut natural forest, appearance of Nile River, Historical buildings, Conservation areas, Tuti Island and Small Nile Islands.

(ii) Sub attractive points such as Small parks, Gardens, Recreational areas, Leisure areas, cultural clubs and sports clubs in Greater Khartoum.

(iii) Blue way system of the Blue, White and Main Nile as open blue corridor system and can be used for water sports, recreation, Nile Cruises, fishery and river transport.

(iv) City Grey ways System.

(v) Public footpaths along Nile River Shores.

(vi) Creation of cornices along Nile River Front.

(vii) Creation of integrated mixed used activities along Nile River Front.

(viii) Ecological greenway system.

(ix) Recreational greenway system.

(x) Cultural greenway system.

7:1:1:6 Skyline of the Nile Riverfront

Skyline of the Nile Riverfront in Greater Khartoum is a sixth type of the Environmental Indicators which composed of a number of variables or indicators that reflect the degree of the adequacy and consistency of the skyline of the Nile River Front. Degree of good or bad skyline of the Nile River due to any sustainable development depends on the satisfactions degree for the following variables or indicators:

(i) General Panoramic view of the Nile River Front.

(ii) Degree of openness and visualization of the Nile River Stream.

(iii) Proportions of buildings heights along the Nile River Front.

(iv) Legislations, laws and building regulations that required to control and manage the development of the Nile River.

(v) Types of trees and vegetation along the Nile River Front.

7:1:1:7 Blue Way of the Nile River

Blue Way of the Nile River is a seventh type of the Environmental Indicators which composed of a number of variables or indicators that measuring a degree of successfulness and impact of any sustainable development that will be applied to the Nile River. Blue way of the Nile River composed of main river stream, river shore and river front of the Nile River in Greater Khartoum with total length in the study area of 67.875 km. Any sustainable development to the Nile River

should consider hydrology, morphology, geotechnical, natural forces, population needs, environmental situations, social aspects, economical aspects and its impact on environment. These requirements for any successful sustainable development to the Nile River as a main Blue Way in Greater Khartoum can be measured and adopted by adequacy and satisfaction for the following variables or indicators:

(i) The adequacy of impact statements that evaluating the sustainable development to the Nile River.
(ii) Elimination of pollution from any sustainable development element.
(iii) Characteristics and nature of the Nile River should not be altered or affected by any sustainable development.
(iv) Sightseeing of the blue way of the Nile River should not be affected by any sustainable development.
(v) Adequacy of legislations, laws and building regulations should be stipulated to control and direct the sustainable development on Nile River.
(vi) Adequacy and efficiency of implementation, monitoring and management of any sustainable development that will be applied to the Nile River.

7:1:1:8 Improving of General Environment in Greater Khartoum

Improving of general environment in Greater Khartoum is the eighth type of the Environmental Indicators which composed of a number of variables or indicators that measuring the contribution of the development in improving the general environment at Greater Khartoum. Contribution of any sustainable development on Nile River in improving the general environment at Greater Khartoum can be measured if that sustainable development satisfies the following variables or indicators:

(i) If the sustainable development on Nile River supports the idea of greenway system at Greater Khartoum.
(ii) If the sustainable development on Nile River not polluted the Blue Way which can be measured by pollution measurements.

(iii) If the sustainable development on Nile River has no direct or indirect negative impact on environment which can be measured by Environmental Impact Assessment EIA.

(iv) If the sustainable development not affect the sightseeing of the Blue Way.

(v) If the sustainable development on Nile River satisfies the legislations, laws and building regulations that is established and stipulated to control and direct the development of the Nile River at Greater Khartoum.

7:1:2 Economic Indicators

Economic Indicators composed of three types measuring a degree of sustainability of a proposed development plan for the Nile River Front at Greater Khartoum. Each type composed of a number of variables or indicators that measuring a degree in rising economical values that is occurred due to any sustainable development that will be implemented on the Nile River Front in Greater Khartoum as specified in below sections:

7:1:2:1 Increase in Land Value

Increase in land value is the first type of Economic Indicators which composed of a number of variables or indicators measuring a degree of increase in land values occurred due to the sustainable development that will be applied to the Nile River at Greater Khartoum, and this can be measured by the following indicators:

(i) Land rate per m^2 before and after the sustainable development project.

(ii) Total income from private and public lands before and after the sustainable development estimation study.

(iii) Land compensation values to lands ownership per m^2.

(iv) Cost Benefit Analysis for the proposed development.

(v) New legislations for land development.

7:1:2:2 Changes of Uses in Lands

Changes of uses in lands is the second type of Economic Indicators which composed of a number of variables or indicators that measuring the changes of uses in land uses due to sustainable development that will be implemented on the Nile River at Greater Khartoum, and this degree of changes can be measured by the following indicators:

(i) Land uses conditions before and after the sustainable development project.
(ii) Annual total income from land uses before and after the development.
(iii) Affect of the new infrastructures to greenway and grey way systems.
(iv) Improving of the environment due to the new sustainable development on the Nile River which can be measured by EIA statements.
(v) Improvement in the general environment of the city which can be measured by the degree of contributions of that development to environment.

7:1:2:3 Contributions to Local and National Economy

Contributions to Local and National Economy is the third type of Economic Indicators which composed of a number of variables or indicators that measuring the contribution of any sustainable development that will be implemented on Nile River in Greater Khartoum, to local and national economy of Sudan. This contribution to local and national economy can be measured by the following variables or indicators:

(i) Total income from those lands before and after the development.
(ii) Proportion of the development income to the old income before the development.
(iii) Opportunities of jobs before and after the development.
(iv) Percentage of the contribution of the development to local economy of Greater Khartoum and National Economy.

7:1:3 Social Indicators

Social Indicators SI composed of three types that measuring a degree of sustainability of a proposed SDNRF at Greater Khartoum. Where each type is composed of a number of variables or indicators that measuring a degree in an improvement of social situations occurred due to sustainable development that will be implemented to the Nile River at Greater Khartoum as specified below:

7:1:3:1 Satisfaction of Population Needs

Satisfaction of Population Needs is the first type of Social Indicators. It is composed of a number of variables or indicators that measuring a degree of satisfaction of population needs and demands in the sustainable development that will be implemented to the Nile River at Greater Khartoum. This degree of satisfaction for population needs can be measured and guessed from the property of the following variables or indicators:

(i) Development issues, which can be measured by the population demands and deficiencies statements for sustainable development on Nile River.
(ii) Population requirements, which can be measured by questionnaires, public participations and workshops for any sustainable development on Nile River.
(iii) Population awareness for any sustainable development.
(iv) Degree of safety to the population and their properties from any risks or hazards.
(v) SDNRF Manual.

7:1:3:2 Improvements in Social Services

Improvements in Social Services is the second type of Social Indicators which composed of a number of variables or indicators that measuring a degree of improvement in social services occurred from sustainable development on the Nile River at Greater Khartoum. This degree of improvement in social services can be measured from property of the following variables and indicators:

(i) Improvement of traffic system which can be measured by methods and types of transports in study area.

(ii) Improvement of public utilities which can be measured by communication systems, amount and source of electricity supply in KWH. Improvement of drinking and disposal waters which can be measured

(iii) by quantity and quality of drinking water in litres\ capita, length and capacity of sewerage disposal system.

(iv) Direct and indirect impacts of the development on environment which can be evaluated by the EIA.

(v) Contribution of the development policies for improving general social services in the proposed development.

7:1:3:3 Improvement of Social Health

Improvement of Social Health is the third type of social indicator. It is composed of a number of variables or indicators that measuring a degree of improvement of social health occurred from the sustainable development which will be implemented to the Nile River at Greater Khartoum. This can be measured due to the degree of adequacy for the following variables or indicators:

(i) Contribution of the development to general health, which can be measured by number and capacity of hospitals and health centres.

(ii) Methods of drainage and disposal systems, which can be measured by their capacities and types.

(iii) Evaluation of the development by EIA.

(iv) Avoidance of pollution in the proposed development plan.

(v) Improvement of general social health elements such as, food, water, housing etc.

These sustainable indicators will be considered and satisfied in the proposed development plan for Nile River Traffic System, Grey Traffic System, Greenway System and Zoning Areas for Nile River Shores in Greater Khartoum as specified in below sections.

7:2 Proposed Development Plan for Nile River Traffic System

The proposed development plan for Sustainable Development of the Nile River Front SDNRF is based on the role and function of the river in Greater Khartoum. The Nile River can be used in supporting different water based activities such as river transportation between and in between areas in Greater Khartoum, river sports, water recreational, fishing, swimming and various water activities. These water based activities will be practiced on and from River Stop Stations within a system in the development plan called Nile River Traffic System. The Nile River Traffic System is composed of 19 hierarchical stations as specified in below section:

7:2:1 Main River Stations

The Main River Stop Station No 1 is extended from Mak Nimir Bridge to Nile River Sport Club with a total length of 500 m and stabilized with concrete walls method as specified in previous chapter. The location of this main station is dominated by Nile River Sport Club which can be developed to cater for different water based recreational activities. In spite of water based recreational activities and because it is near the CBD area of Khartoum it will also be used for river traffic transportations methods, water sports, a station for long and short trips, a station for different water used activities and to be used as one of the main attractive points of greenway system as it will be discussed later in the proposed development plan for greenway system in Greater Khartoum.

7:2:2 Sub Main River Stations

There will be 5 Sub Main River Stations in this proposed development plan for Nile River Traffic System in Greater Khartoum. These stations' walls are either stabilized with concrete walls methods for Blue and Main Nile stations or raking stones walls method for White Nile Stations. These stations will be used for traffic and water based recreational activities. Each station will have a total length of 200 m as specified in the previous chapter. These Sub Main River Stations in the proposed development plan for Nile River Traffic System are specified in Table 7-1.

Table 7-1 Specifications of Sub Main River Stations in the proposed development plan of the Nile River Traffic System (source the author)

Station No	Length/m	Method of Station Stabilization Walls	Location of the Station	Shore No	River Name
2	200 m	Concrete Walls	Friendship Hall facing Khartoum	3	Blue Nile
6	200 m	Concrete Walls	Manshia Bridge facing Khartoum	13	Blue Nile
9	200 m	Raking Masonry	Engaze Bridge facing Omdurman	16	White Nile
12	200 m	Raking Masonry	Salha Bridge facing Khartoum	15	White Nile
3	200 m	Concrete Walls	Tuti Island	4	Confluences of the Blue and White Nile

Table 7-1 illustrates that the sub stations are located near the CBD areas and they will act as sub attractive points in the greenway system in Greater Khartoum.

7:2:3 River Stop Stations

The Nile River Traffic System composed of 13 River Stop Stations integrated with above ones. The stations walls either stabilized with Concrete Walls Method for stations on Blue and Main Nile or Raking Bricks Walls Method for stations on White Nile where each one with total length of 100m. These stations will be used for different Nile traffic methods and Nile sports activities. These River Stop Stations in the proposed plan for River Traffic System in Greater Khartoum are specified in Table 7-2.

Table 7-2 Specifications of River Stop Stations in the proposed development plan of the Nile River Traffic System (source the author)

Station No	Length/m	Method of Station Stabilization Walls	Location of the Station	Shore No	River Name
4	100 m	Concrete Walls	Friendship Hotel facing Khartoum	6	Blue Nile
5	100 m	Concrete Walls	Garden City facing Khartoum	13	Blue Nile
7	100 m	Concrete Walls	Manshia Bridge facing Khartoum North	14	Blue Nile
8	100 m	Concrete Walls	Kuku Area facing Khartoum North	14	Blue Nile
19	100 m	Concrete Walls	Old Nile Bridge facing Khartoum North	2	Blue Nile
10	100 m	Raking Bricks Walls	Engaze Bridge facing Khartoum	15	White Nile
11	100 m	Raking Bricks Walls	Shagra in Khartoum	15	White Nile
13	100 m	Raking Brick Walls	Salha Bridge facing Omdurman	16	White Nile
14	100 m	Concrete Walls	Almorada Area in Omdurman	9	Main Nile
15	100 m	Concrete Walls	Shambat Bridge facing Omdurman	12	Main Nile
16	100 m	Concrete Walls	Shambat Bridge facing Khartoum North	11	Main Nile
17	100 m	Concrete Walls	Tuti Island	1o	Confluences of the Blue and White Nile River
18	100 m	Concrete Walls	Tuti Island	5	Confluences of the Blue and White Nile River

Table 7-2 illustrates that the 13 River Stop Stations are connected with the different areas of Greater Khartoum and will also assist the greenway system. The proposed plan for River Traffic System will satisfy previous sustainable indicators as illustrates in Fig 7-1.

Fig 7-1 Proposed plan for River Traffic System (source the author)

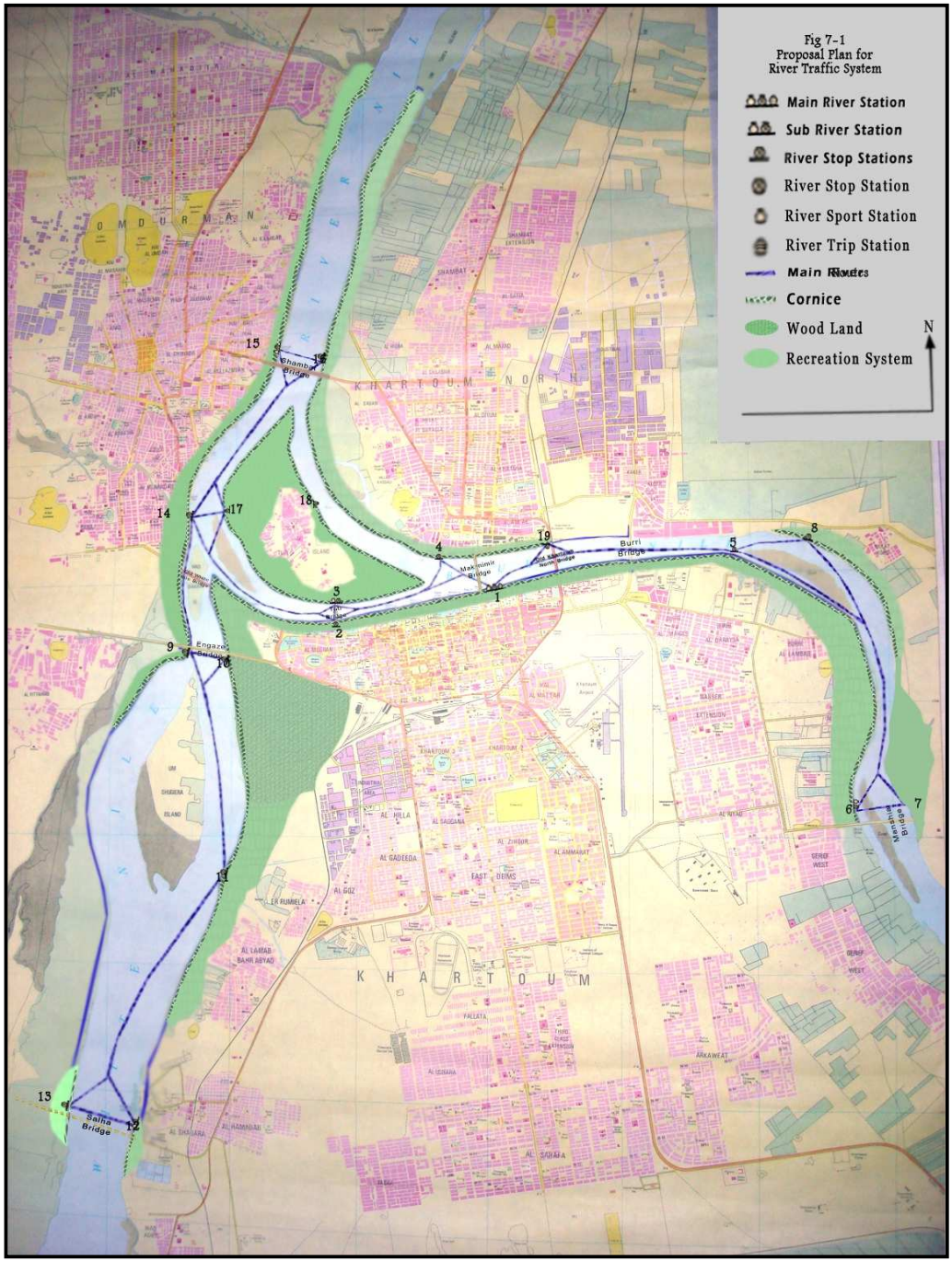


Fig 7-1 illustrates the utilization and uses of the Nile River as main way in traffic and recreational activities in Greater Khartoum.

7: 3 Proposed Development Plan for Grey Way Traffic System

Grey Way Traffic System composed of asphalt streets beside Nile Shores. The existing asphalt streets on Nile River Shores are very short which is 14.75 km compared to the total length of the River Shores which is 67.875 km. The total length of the asphalt street that faces Khartoum is 9.5 km and that faces Omdurman is 5.25 km. The proposed development plan for Grey Way Traffic System in Greater Khartoum composed of asphalt streets adjacent to the Nile Shores for the users of those shores and side roads for other users, so as not to cause congestion on Nile Shores. The system contains main and sub intersections that will assist in carrying traffic away from the proposed cornice along Nile River Front. The Grey Way Traffic System integrated with River Traffic System in the proposed development plan for the Nile River Shores will lead to:

- Better communication between and in between different areas in Greater Khartoum.
- Accessibility to the Nile River Shores.
- Coherence of the proposed development elements.
- Sky line of the Nile River Front in Greater Khartoum.
- Establishment of better infrastructure.
- Continuation of the different development elements with each other without obstruction.
- Decrease pollution to the Nile River.
- Improve the general environment of Greater Khartoum.
- Support the idea of greenway system in study area.

The Grey Way Traffic System composed of main roads and side roads in Greater Khartoum. The system connects Khartoum, Omdurman and Khartoum North by asphalt streets and bridges as illustrates in Fig 7-2.

Fig 7-2 Proposed Plan for Grey Way Traffic System (source the author)

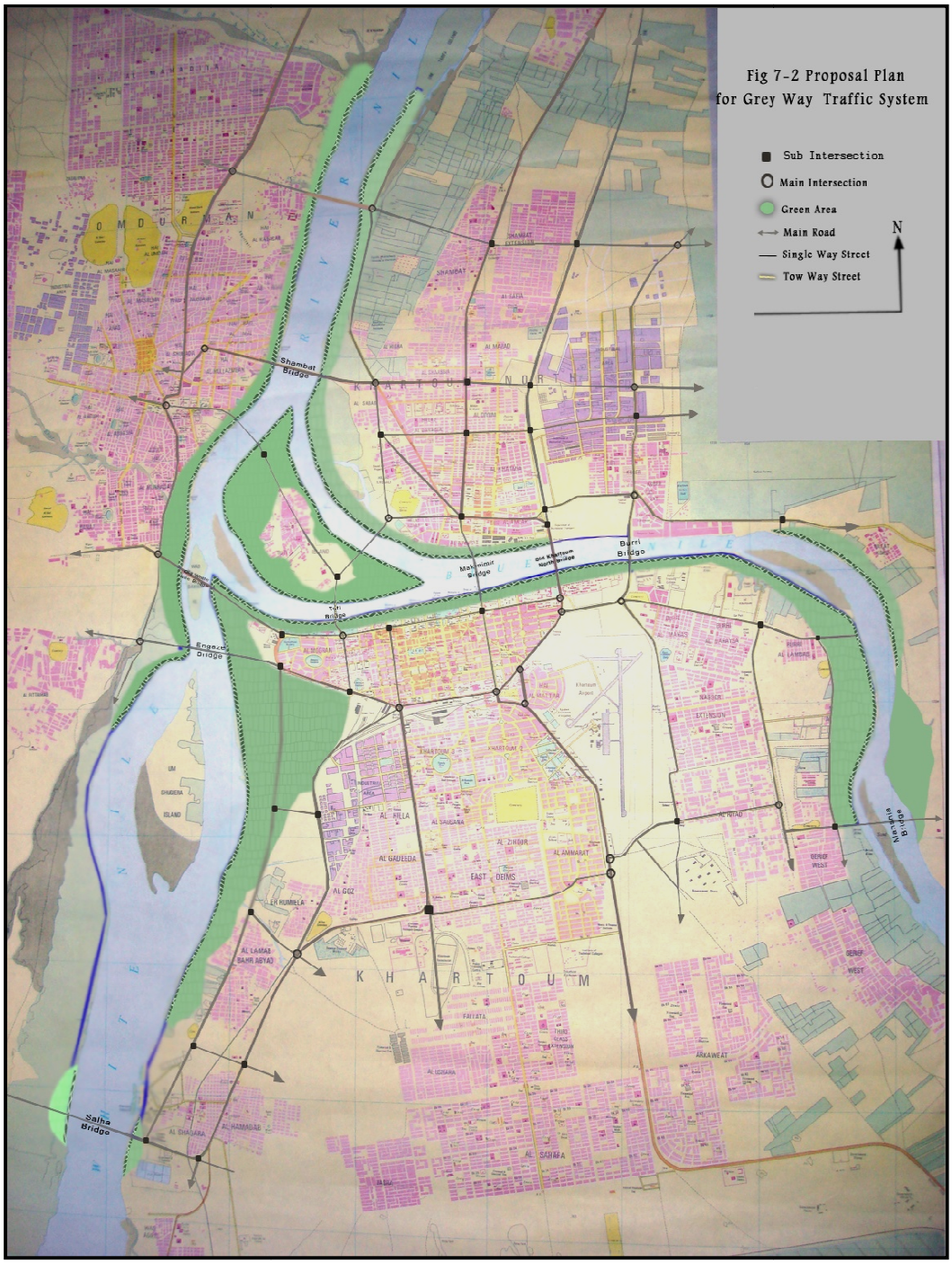


Fig 7-2 illustrates the integration of the asphalt streets or Grey Traffic System with the Nile River Traffic System in the proposed development plan.

7:4 Proposed Development Plan for Cornice and Greenway System

The proposed development plan for Greenway System in Greater Khartoum will satisfy the ten indicators specified previously that measuring a degree of any successful sustainable development which will be due to its contributions to the Greenway System at Greater Khartoum. The proposed development plan for Greenway System on the Nile River Shores composed of essential elements or main attractive points, sub attractive points and attractive points. The main elements composed of main recreational, cultural, historical, parks and other attractive activities on potential Nile Shores. Sub attractive points composed of sub recreational, cultural, river stations, small parks between main parks and other attractive activities on Nile Shores. Attractive points composed of small recreational, cultural and any other attractive points on different Nile Shores. Components and elements in the Proposed Development Plan for Greenway System in Greater Khartoum are composed of:

7:4:1 Main Attractive Points

The Main Attractive Points in this development plan composed of Tuti Island, Mogran Parks at the confluences of the Blue and White Nile, Elmorada Parks, East and West side of the White Nile at Engaze Bridge, East and West side of the Main Nile River at Shambat Bridge, Friendship Hotel Park, West side of the Blue Nile at Manshia Bridge and areas at the East side of the White Nile at Salha Bridge.

7:4:2 Sub Main Attractive Points

The Sub Main Attractive Points composed of those attractive points integrated with river stop stations and between the main attractive points or the hub points of the greenway system.

7:4:3 Attractive Points

The Attractive Points composed of those attractive points between the Sub Main Attractive Points of the greenway system.

7:4:4 Cornice

The Cornice in the proposed development plan is extended on both sides of the Nile River Front in the study area with total length of 67.875 km. People have a right of accessibility and use of riverfront without restriction and this issue can be stipulated by laws and regulations.

7:4:5 Greenway Routes

Greenway Routes composed of vegetations and landscape along the Nile River Front and integrated with the cornice.

7:4:6 Footpaths

Footpaths are composed of paths along the cornice in the study area. These footpaths in the proposed development plan admit people to use the Nile River Front and the current situation will be changed where there are only 14.75 km accessible to the river and they are without footpaths.

7:4:7 Mixed Uses Urban Elements

Mixed Uses Urban Elements in the proposed development plan are composed of the different development elements that are required for satisfying population needs in the proposed development plan for SDNRF at Greater Khartoum.

The proposed development plan will satisfy the requirements of the previous indicators that measure the quality of Cornice and Greenway System by creation of open public parks, recreational elements, cornices on both sides of the Nile River, water based sports, integrated urban elements and stipulation of laws and regulations that required for directing and controlling the development of the Nile River Shores in Greater Khartoum. The proposed development plan for Cornice and Greenway System in Greater Khartoum is illustrates in Fig 7-3.

Fig 7-3 Proposed Plan for Greenway System at Greater Khartoum (source the author)

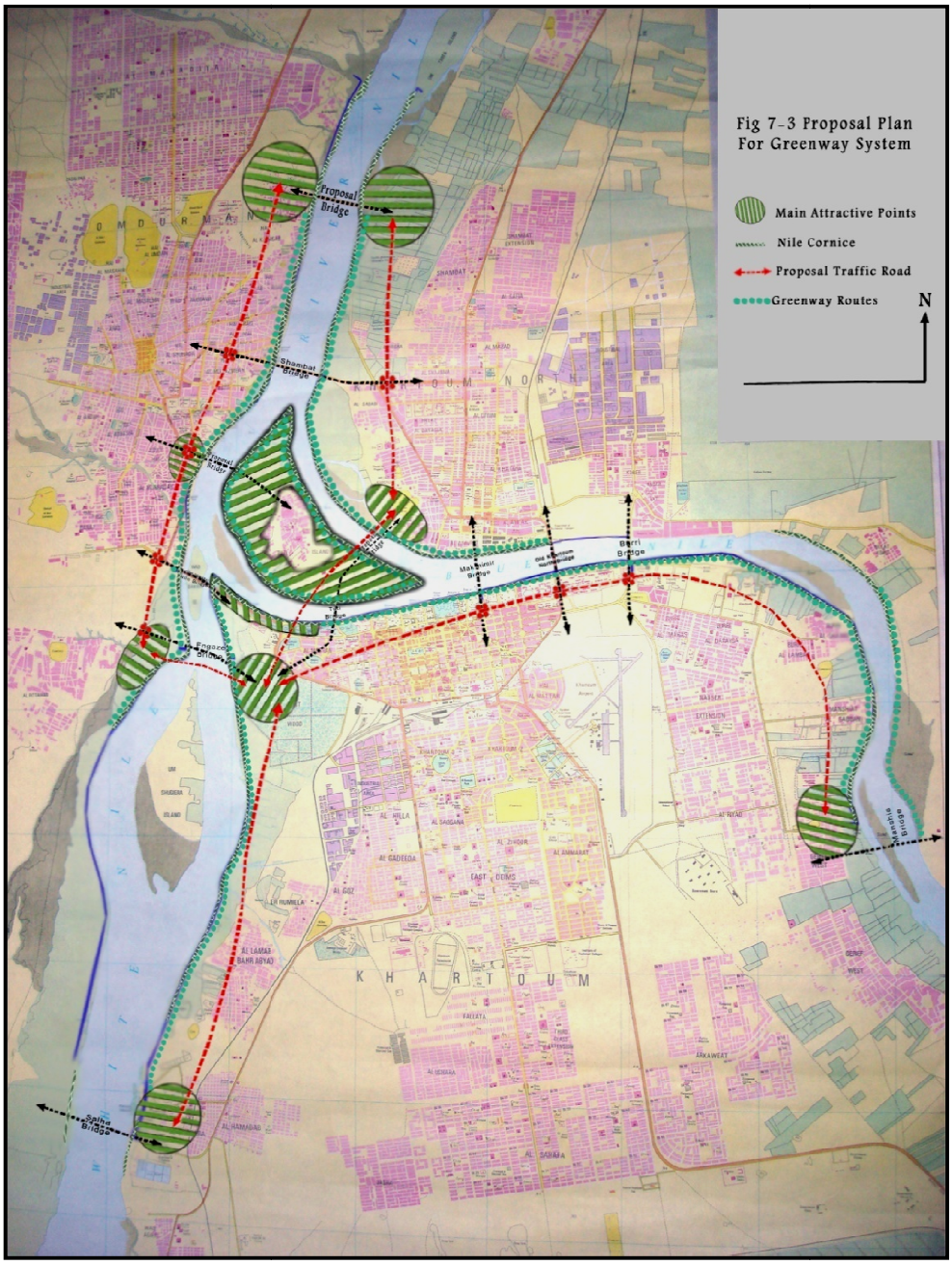


Fig 7-3 illustrates that the main attractive points of the greenway system were located on both sides of the Nile River, the role of the river in the greenway system and the integrated traffic that connected the main points of the greenway system in Greater Khartoum.

7:5 Proposed Development Plan for Zoning Areas in Greater Khartoum

Proposed Development Plan for Zoning Areas in Greater Khartoum will develop a set of guidelines for the development of the Nile River Shores. The development plan will establish zoning for different development areas on Nile Shores so as to direct and formulate the development on those Nile Shores according to the development plan. The implementation of those elements in each zone will be according to the guidelines, regulations and legislations that stipulated from local and national authorities for controlling and directing the development of the SDNRF at Greater Khartoum.

The previous five indicators that measure the contributions of the proposed development plan that is applied to the Nile River Shores will improve the general environment of Greater Khartoum and will be satisfied by the proposed development plan. Satisfactions of those indicators by the proposed development plan will be as specified in below section:

- The proposed development plan fulfils the idea of Greenway System as illustrated in Fig 7-3.
- The sustainable development of the Nile River Shores will be implemented according to the SDNRF Manual.
- The development will create new infrastructures as illustrates in Fig 7-2.
- The development plan will establish a new ecological way system.
- The sustainable development plan satisfies methods of stabilization banks and application of sustainable development on the shores adjacent to those stabilized banks.
- The development plan will create zoning for different land uses as illustrates in Fig 7-4.

Fig 7-4 Proposed Development Plan for Zoning Areas (source the author)

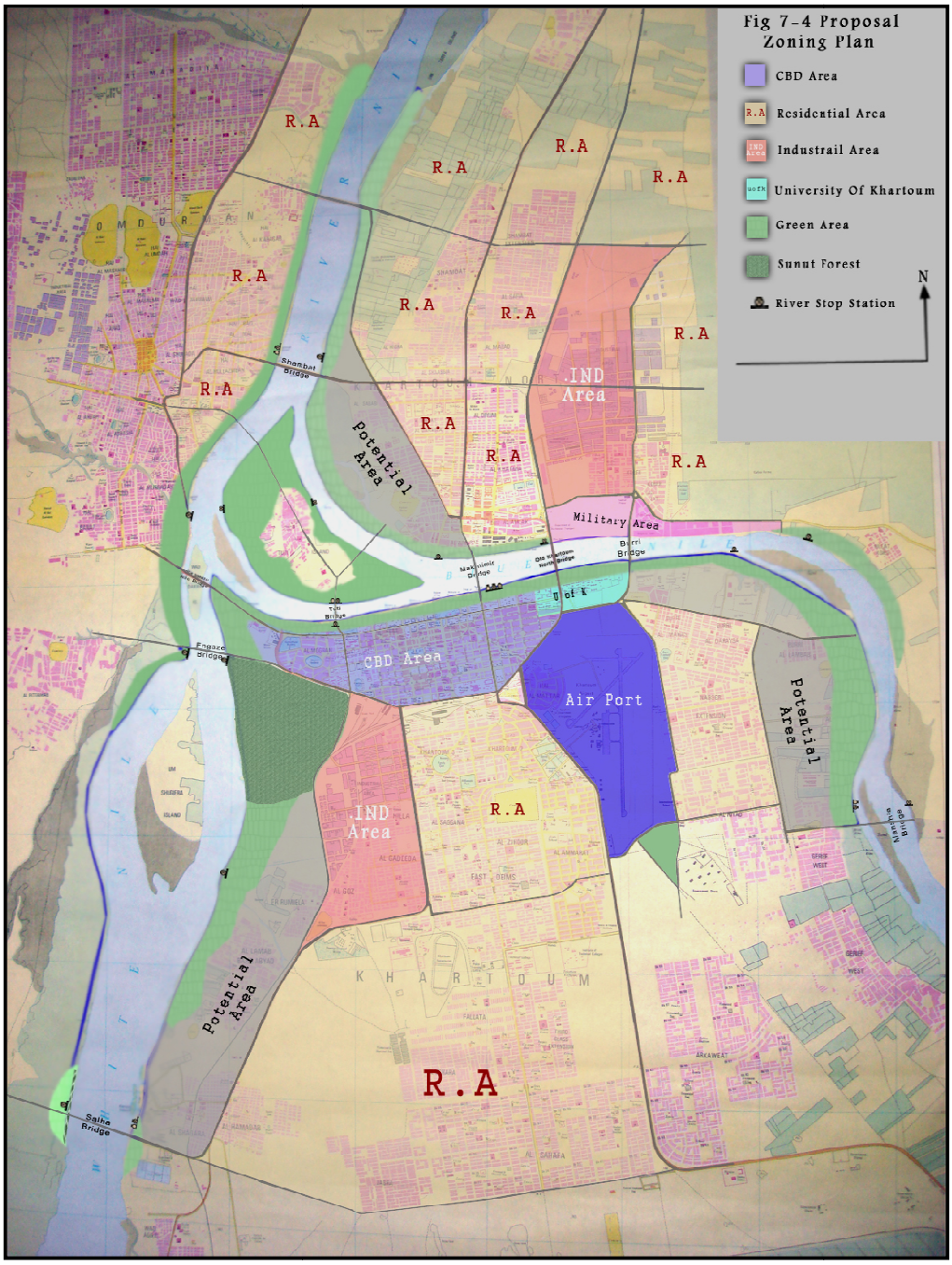


Fig 7-4 illustrates that the Cornice is extended on both sides of the Nile River Front and different zones are located adjacent to the Cornice.

7:6 Potential Shores and Riverfronts of the Nile River in Greater Khartoum

The most potential shores and their adjacent riverfronts are those Nile Shores in Greater Khartoum that have specific characteristics and potentialities for supporting proposed development as specified in below sections.

7:6:1 Shore and Riverfront 1

Shore and Riverfront 1 is located on the Blue Nile facing Khartoum. It is extended from Burri Bridge to Mak-Nimir Bridge. The total length of the shore is 3.00 km without stabilization banks and containing floodplain area of about 40 acres used in traditional agriculture. This shore is potential for the following reasons:

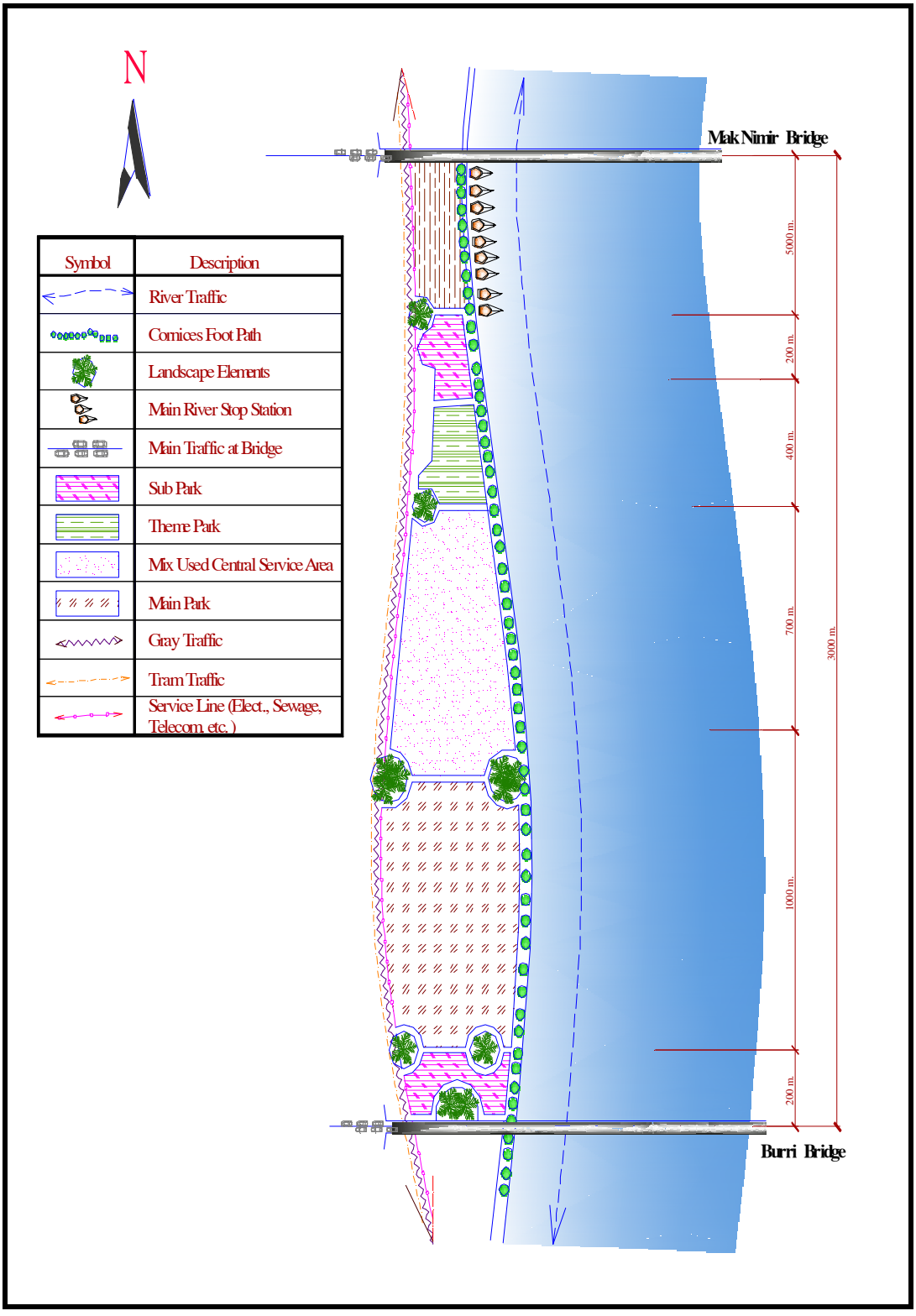
(i) It is adjacent to the CBD area at Khartoum.
(ii) Main river sport club in Sudan is located on it.
(iii) Main buildings of the University of Khartoum are located on it.
(iv) Some of the important governmental buildings are located on it.
(v) The shore is accessible and with good traffic.
(vi) It could have continuation cornice with shore 3.

This potential shore is near the CBD area and many of historical and important buildings are located on it as specified in the previous chapters. The shore is stabilized in the proposal development plan by concrete walls method for water based recreational activities with total length of 500 m while the remaining bank which is 2500 m is stabilized with concrete and brick walls method. The water based recreation in the proposal development plan will consume the main water recreational activities such as; fishing, boating, swimming, river sports, fountains etc. The asphalt street along the shore will be used only for the users so as to eliminate congestion along the cornice and beside it is the tram line. Also beside traffic lines there will be; communication lines, service lines, main sewerage lines, electric powers lines etc. Generally the main development issues in the proposal development plan for this potential shore on the Blue Nile in Greater Khartoum are as specified in below Table 7-3 and Fig 7-5.

Table7-3 Main Development Issues on Shore and Riverfront 1 (source the author)

Item	Development Elements	No	Length/ m	Area/ Acre
1	Main Traffic Systems:- 1- Asphalt Street. 2- Tram Line. 3- River Traffic System.		3000	
2	Main River Station includes:- 1- Water Based Recreation. 2- River Traffic System. 3- Cruisers. 4- Water urban activities.	1	500	6
3	Cornice beside the bank:- 1- Footpath. 2- Walkways Routes. 3- Recreational Activities.	1	3000	
4	Greenway Routes beside the cornice:- 1- Green Landscape areas. 2- Vegetations. 3- Fountains. 4- Sculptures.	1	3000	
5	Main Landscape Elements	7		
6	Main Park	1	1000	13
7	Theme Park	1	400	5
8	Sub Park	2	Each 200	Each 2.5
9	Mix Used Central Service Area:- 1- Restaurants and cafes. 2- Recreational Activities. 3- Commercial Activities. 4- Service Activities. 5- Others.	1	700	9
10	Main Cars Parking Area	1	500	2.5
11	Services Lines beside the asphalt street.		3000	

Fig 7-5 Proposal Development for Shore (1) on the Blue Nile (source the author)



7:6:2 Shore and Riverfront 8

Shore and Riverfront 8 is located on the White Nile facing Omdurman. It is extended from Old White Nile Bridge to Engaze Bridge. The total length of the shore is 1.250 km without stabilization banks and containing floodplain area of about 88 acres. This shore is potential for the following reasons:

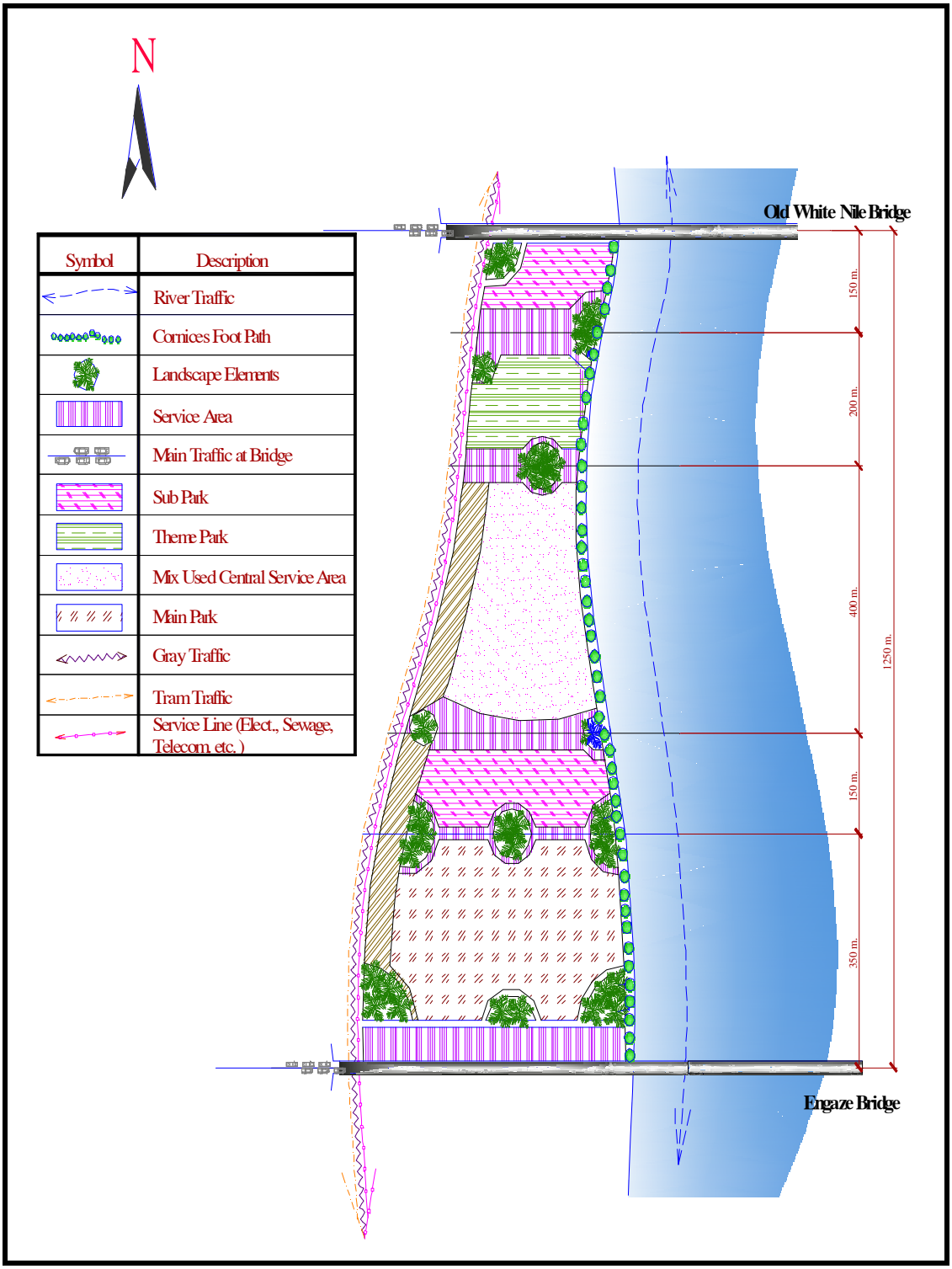
(i) It has unique location near the confluences of the Blue and White Nile.
(ii) It is near Omdurman CBD area.
(iii) It is facing the new CBD area for Africa that will be on shore 7.
(iv) It contains large floodplain area.
(v) There is no recreational area near this important area.
(vi) It is dominated the two important bridges that are; the Old White Nile Bridge and Engaze Bridge.

This potential shore is near the CBD of Omdurman area and many important buildings are located on it in spite of that it is facing the new CBD area for Africa on Shore 7 as specified in the previous chapters. The shore is stabilized in the proposal development plan by raking brick or masonry walls method with total length of 1250 m. The shore in the proposal development plan will consume water based recreational activities such as; fishing, boating, swimming, river sports, fountains etc. Also different urban elements to satisfy population needs will be located on this potential shore and riverfront in the proposal development plan. The traffic in the proposal development plan will be by asphalt street along the riverfront will be used only for the users so as to eliminate congestion along the cornice. Beside it there will be tram line and river traffic system. The communication lines, service lines, main sewerage lines, electric powers lines etc in the proposal development plan are located beside the proposal asphalt street. The proposal development plan composes of various urban elements such as; public parks, theme parks, recreational elements, landscape elements, service and mix used elements. Generally the main development issues in the proposal development plan for this potential shore on the Blue Nile in Greater Khartoum are as specified in below Table 7-4 and Fig 7-6.

Table7-4 Main Development Issues on Shore and Riverfront 8 (source the author)

Item	Development Elements	No	Length/ m	Area/ Acre
1	Main Traffic Systems:- 1- Asphalt Street. 2- Tram Line. **3-** River Traffic System.		1250	
2	Cornice beside the bank:- 1- Footpath. 2- Walkways Routes. 3- Recreational Activities.	1	1250	
3	Greenway Routes beside the cornice:- 1- Green Landscape areas. 2- Vegetations. 3- Fountains. 4- Sculptures.	1	1250	
4	Main Landscape Elements	12		
5	Main Park	1	350	15
6	Theme Park	1	200	8
7	Sub Park	2	Each 150	Each 5
8	Mix Used Central Service Area:- 1- Restaurants and cafes. 2- Recreational Activities. 3- Commercial Activities. 4- Service Activities. 5- Others.	1	400	20
9	Main Cars Parking Area	1	400	3
10	Services Lines beside the asphalt street.		1250	

Fig 7-6 Proposal Development for Shore (8) on the White Nile (source the author)



7:6:3 Shore and Riverfront 9

Shore and Riverfront 9 is located on the Main Nile facing Omdurman. It is extended from Old White Nile Bridge to Shambat Bridge. The total length of the shore is 3.750 km where 1.250 km with stabilization banks and 2.500 km without stabilization banks and containing floodplain area of about 70 acres used in agriculture. This shore is potential for the following reasons:

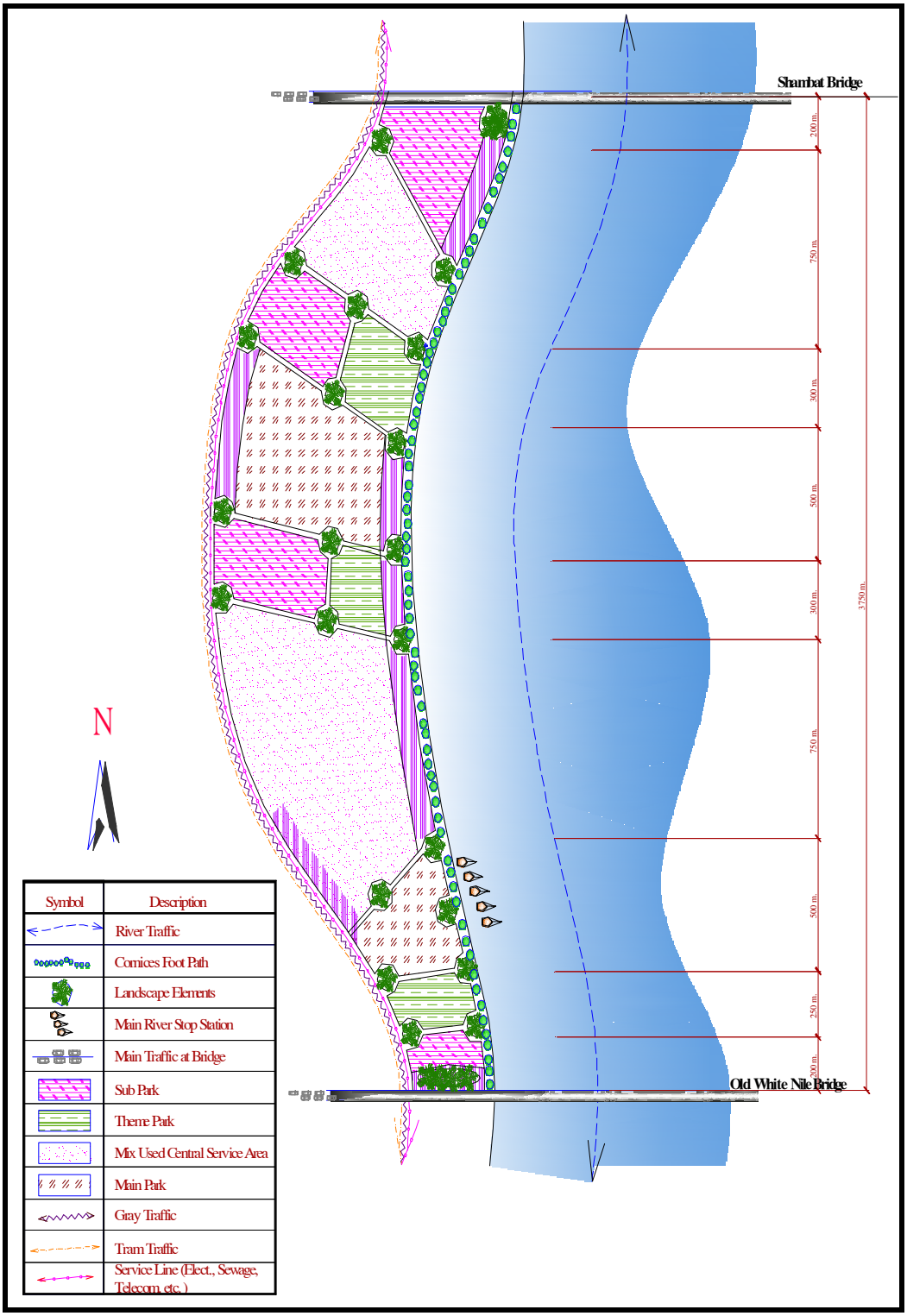
(i) It is adjacent to Omdurman CBD area.
(ii) The main television and radio stations for Sudan are located on it.
(iii) The main theatre in Greater Khartoum is located on it.
(iv) Most of important public recreational parks are located on it.
(v) Main important cultural clubs are located on it.
(vi) The shore is accessible and with good traffic.
(vii) The shore contains large floodplain area which can be developed in the proposal plan for different urban elements.

This potential shore is near the CBD of Omdurman area and many important buildings are located on it as specified above. The shore is stabilized in the proposal development plan by concrete walls method for the river stop station No 14 with total length of 100 m. This station is located at Almorda near Omdurman CBD area. The remaining of the shore is stabilized in the proposal plan with concrete and brick walls method with total length of 2400 m. The shore in the proposal development plan will consume water based recreational activities on the river stop station No 14 such as; fishing, boating, swimming, river sports, fountains etc. The traffics in the proposal development plan are by Asphalt Street, river traffic methods and tram lines along the riverfront along the proposal cornice. Beside the Asphalt Street in the proposal plan there will be communication lines, service lines, main sewerage lines, electric powers lines etc. The proposal development plan composes of various urban elements such as; public parks, theme parks, recreational elements, landscape elements, service and mix used elements. Generally the main development issues in the proposal development plan for this potential shore on the Blue Nile in Greater Khartoum are as specified in below Table 7-5 and Fig 7-7.

Table7-5 Main Development Issues on Shore and Riverfront 9 (source the author)

Item	Development Elements	No	Length/ m	Area/ Acre
1	Main Traffic Systems:- 1- Asphalt Street. 2- Tram Line. 3- River Traffic System.		3750	
2	Main River Station includes:- 1- Water Based Recreation. 2- River Traffic System. 3- Cruisers. 4- Water urban activities.	1	100	
3	Cornice beside the bank:- 1- Footpath. 2- Walkways Routes. 3- Recreational Activities.	1	3750	
4	Greenway Routes beside the cornice:- 1- Green Landscape areas. 2- Vegetations. 3- Fountains. 4- Sculptures.	1	3750	
5	Main Landscape Elements	27		
6	Main Park	2	Each 500	Each 8
7	Theme Park	3	Each 300	Each 4
8	Sub Park	4	Each 200	Each 2
9	Mix Used Central Service Area:- 1- Restaurants and cafes. 2- Recreational Activities. 3- Commercial Activities. 4- Service Activities. 5- Others.	2	Each 750	Each 12
10	Main Cars Parking Area	1	500	3
11	Services Lines beside the asphalt street.		3000	

Fig 7-7 Proposal Development for Shore (9) on the Main Nile (source the author)



7:7 Examples of the Proposal Stabilization Method for the Blue Nile Banks

Most of the Blue Nile Shores in the proposal development plan are stabilized with; Concrete Walls Method or Concrete and Brick Walls Method. The concept for the left bank is illustrated in Fig 7-8 and Fig 7-9 while on the right bank is illustrated in Fig 7-10 and Fig 7-11.

Fig 7-8 Stabilization of the Left Nile Banks with Concrete Walls Method (source the author)

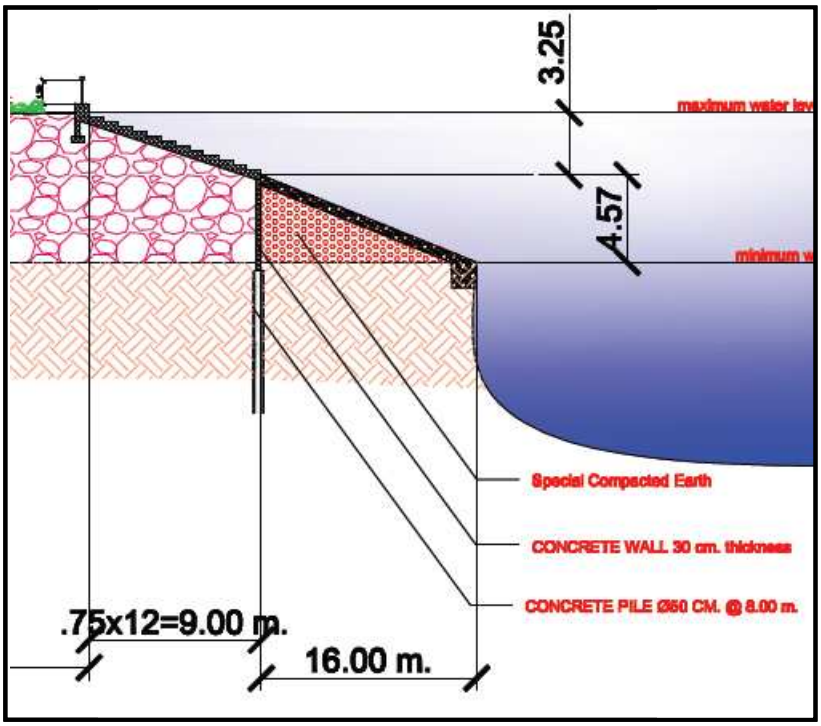


Fig 7-9 Cross Section of the Development on the Left of the Blue Nile Banks (source the author)

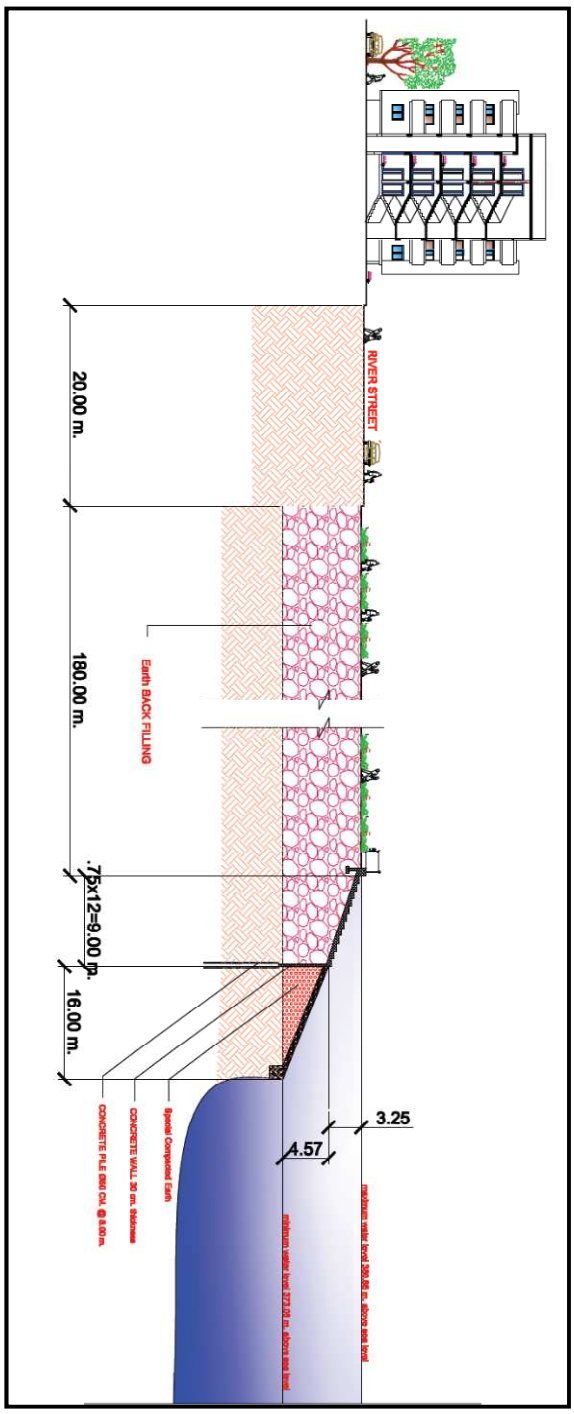


Fig 7-10 Cross Section of the Development on the Right of the Blue Nile Banks (source the author)

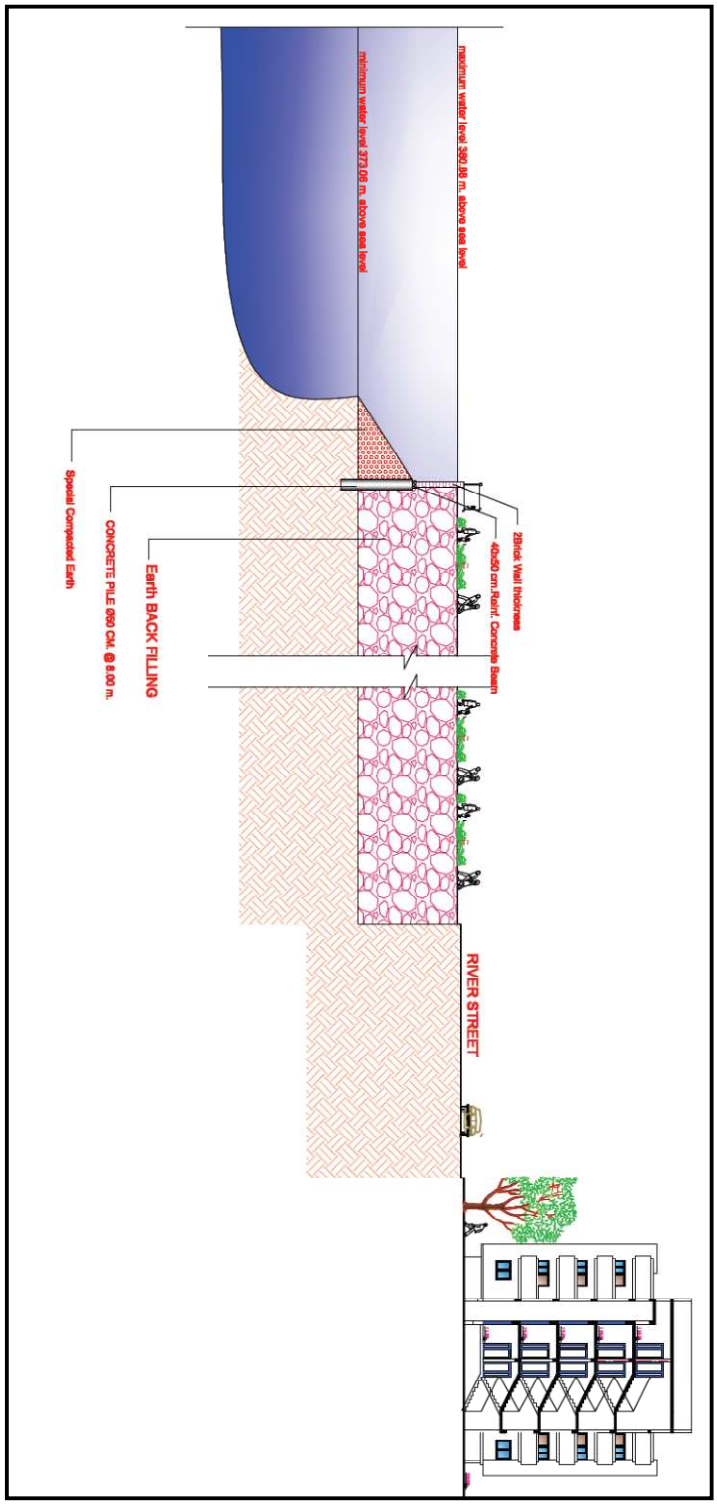
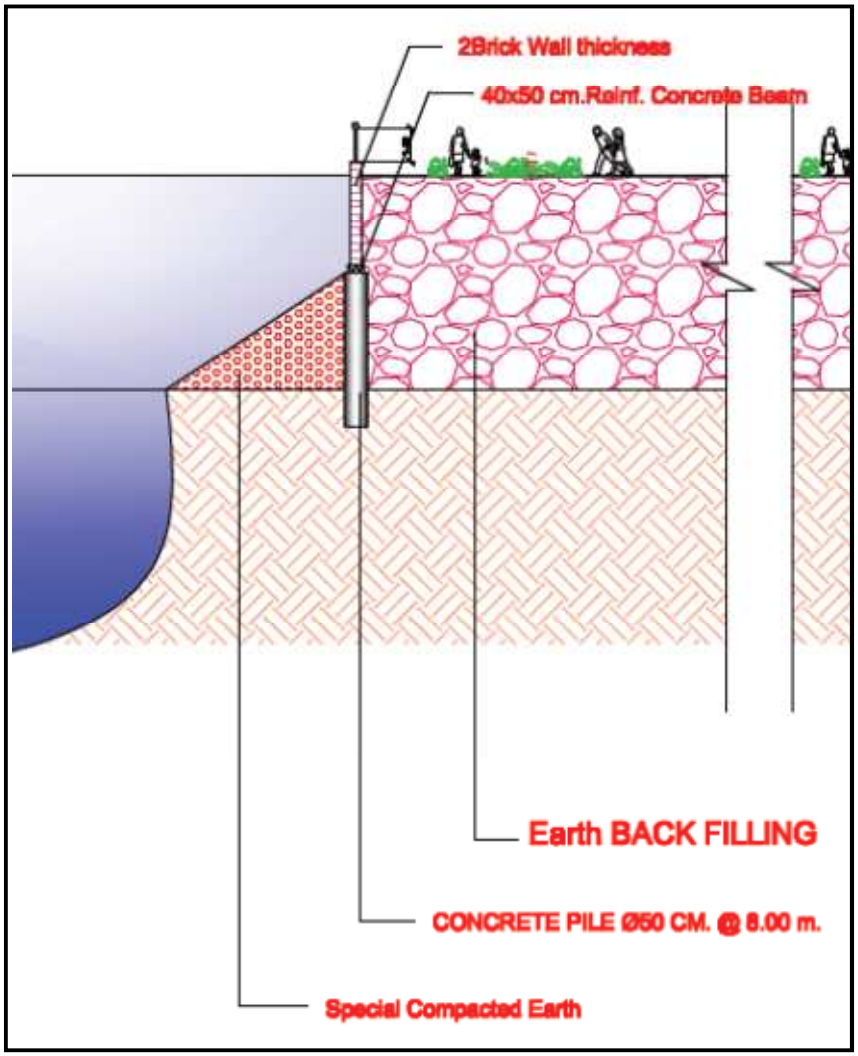


Fig 7-11 Stabilization of the Right Blue Nile Banks with Concrete and Brick Walls Method (source the author)



7:8 Examples of the Proposal Stabilization Method for the White Nile Banks

The White Nile Shores Are characterized with long wide shallow shores. Therefore most of them in the proposal development plan are stabilized with; Raking Brick Walls Method or Masonry on Dry Pitching Earth Embankment Method. The concept for the left bank is illustrated in Fig 7-12 and Fig 7-13 while on the right bank is illustrated in Fig 7-14 and Fig 7-15.

Fig 7-12 Stabilization of the Left White Banks with Raking Brick Walls Method (source the author)

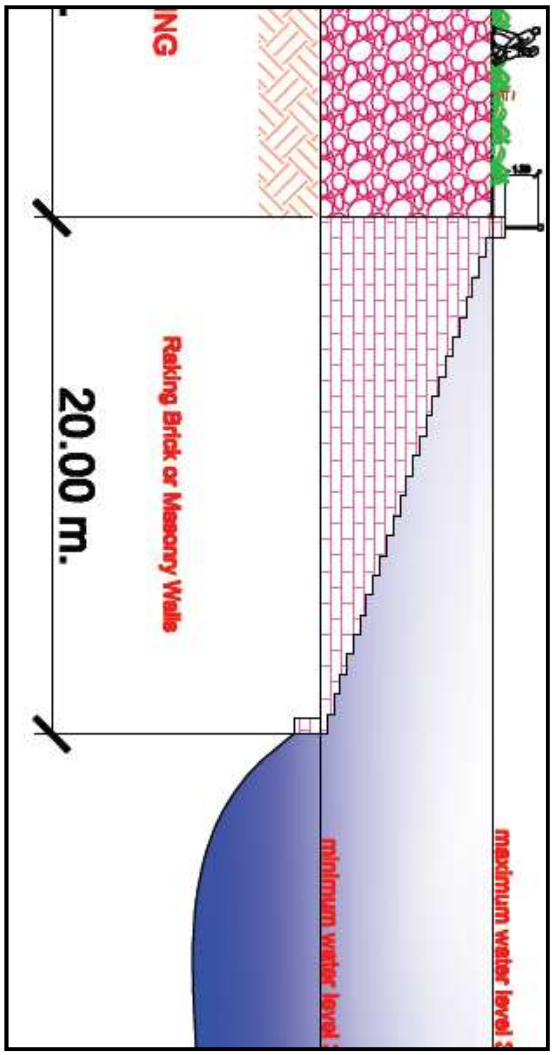


Fig 7-13 Cross Section of the Development on the Left of the White Nile Banks (source the author)

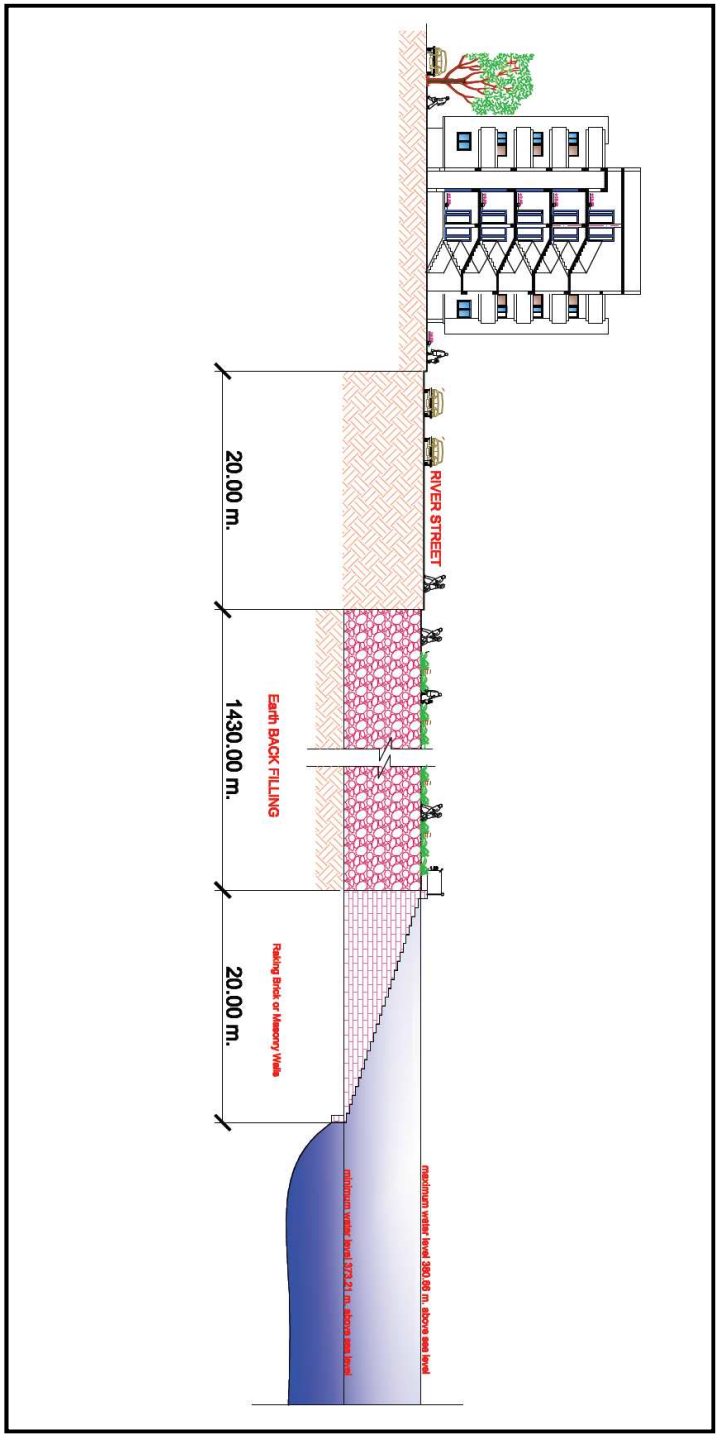


Fig 7-14 Cross Section of the Development on the Right of the White Nile Banks (source the author)

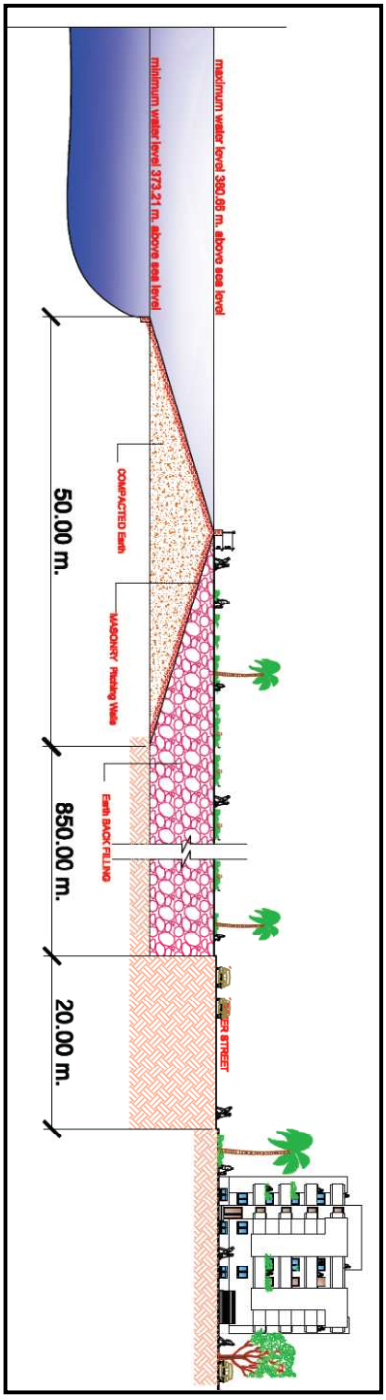
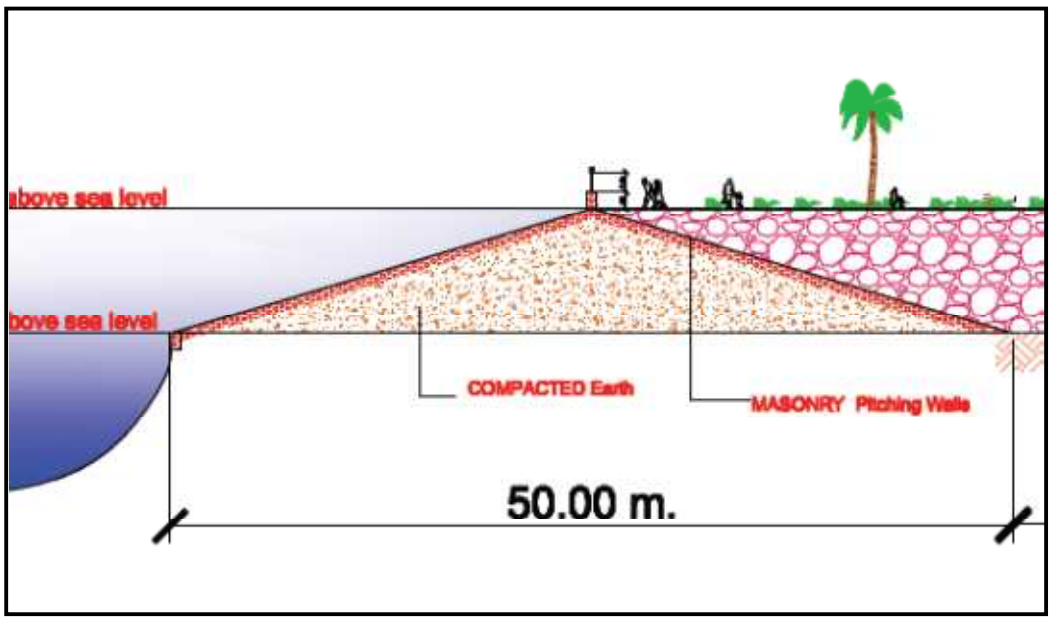


Fig 7-15 Stabilization of the Right White Banks with Masonry on Dry Pitching Earth Embankment Method (source the author)



7:9 Summary of Chapter Seven

Chapter Seven developed data derived from previous chapters and established a set of guidelines for sustainable indicators and proposed development plans that tackled the second area in this study. The chapter firstly, established Sustainable Indicators that measured the proposed sustainable development for the Nile River Front at Greater Khartoum and they are related to:

- Environmental Indicators that measuring environmental issues such as methods of stabilization banks which discussed in the first area of this study, river traffic system, accessibility to the Nile River Shores, degree of flexibility of any development, sky line of the Nile River Front resulted from the development, degree of the Nile River as main blue way in Khartoum, potentialities of the greenway system in the study area and improvement of the general environment in Greater Khartoum.

- Economic Indicators which considered economic issues related to increase in land values due to the proposed development of the Nile Shores, degree of changes in land uses and contribution of the development to local and national economy.

- Social indicators which considered social issues tackled satisfaction of population needs and improvement of environmental situations.

The chapter formulated data derived from previous chapters incorporated with sustainable indicators and develop set of guidelines to propose development plan for Sustainable Development of the Nile River Front in Greater Khartoum. The proposed plan tackled urban issues and established infrastructure for the 16 Nile Shores such as:

- Proposed development plan for the Nile River Traffic System which composed of Main, Sub Main and River Stations where these total stations are 17 stations. The system established new urban elements such as new transportation methods, water sports, water recreational activities and utilization of the Nile River for different urbanization activities in Greater Khartoum.

- Proposed development plan for the Grey System incorporated with the River Traffic System that led to improve the general infrastructure and accessibility to Nile Shores in the study area.

- Proposed development plan for cornice and greenway system which composed of main, sub main and attractive points. The greenway system develops a set of guidelines for developing Nile Shores and creation of new urban elements in Greater Khartoum.

- Proposed development plan for zoning areas that led to develop a set of guidelines that control and direct the development in the study area.

CHAPTER EIGHT: TESTING THE GUIDELINES

(REFINEMENT AND EVALUATION)

8:0 Introduction

Chapter Eight, based on the previous chapter, will specify the output for the two areas that are tackled in this study that are related to methods of stabilization Nile Banks and development of those Nile Shores along those banks in Greater Khartoum. The chapter will specify the guidelines and the main development elements in the final version of the proposed development plan for the Sustainable Development of the Nile River Front SDNRF at Greater Khartoum.

For the first area the chapter will summarize the guidelines for the suitable methods of stabilizing each bank of the Blue Nile, White Nile, Main Nile and Confluences Banks as summarized below:

- Methods of stabilizing Blue Nile Banks where it is considered, due to its characteristics and hydrology, it is a main driving force for stabilization methods that will be used for the Nile Banks. The Blue Nile Banks based on hydrology, characteristics, river pattern system, morphology and banks soils are stabilized with concrete walls, concrete and bricks walls, brick walls and timber piling for those banks facing the military areas.
- Methods of stabilizing White Nile Banks due to its stable flow, banks soils, river pattern system and wide shore, its banks are stabilized with raking bricks walls, stones on dry pitching earth embankments and compacted earth embankments for rural banks.
- Methods of stabilizing Main Nile Banks related to river studies are concrete walls, concrete and bricks walls and brick walls method.
- Methods of stabilizing Confluences Banks at Tuti Island based on river studies are concrete walls and concrete and bricks walls method.

These methods of stabilization banks are evaluated due to the summation of the numerical values for each stabilization method for the 16 Nile Banks.

The chapter also tackled the second area of this study by establishing guidelines for developing the 16 Nile Shores and River Fronts adjacent or along those Nile Banks. The proposed plan for Sustainable Development of the Nile River Front SDNRF at Greater Khartoum will established development issues and guidelines for:

- River Traffic System and Grey Traffic System in the study area that lead to better utilization of the Nile River as main blue way and corridor in Greater Khartoum.

- Cornice and Greenway System that characterized and make special identity for Khartoum urban areas based on main attractive, sub attractive and attractive points in the study area on both sides of the Nile Shores.
- Mixed Use Urban Elements on both sides of the Nile Shores that leads to make Nile Shores more life and improve the environment of the study area.
- Laws and regulations that required for formulation polices that able to control and direct the development of the Nile Shores.

These development issues and guidelines in the final version of the development plan for the 16 Nile Shores will be evaluated from the summation of the numerical values of the sustainable indicators. The sustainable indicators are related to environmental indicators, economic indicators and social indicators.

8:1 Final Version of the Proposed Development Plan for SDNRF at Greater Khartoum

The Final Version of the Proposed Development Plan for Sustainable Development of the Nile River Front SDNRF at Greater Khartoum is directing and controlling the development of the Nile River Shores along the Blue, White and Main Nile River. The development plan tackles the sixteen shores along the Nile River with total length of 67.875 km including military areas along the Blue Nile Shores. The plan tackles the main two areas of this study which are methods of stabilization banks and development of the Nile River Shores as summarized in below sections:

8:1:1 Methods of Stabilization Banks for each of the Nile River Shores

Methods of stabilizing banks for each of the sixteenth Nile River Shores is the first area in this study as specified in chapter six. The study specified and illustrates the suitable stabilization methods for each bank of the Blue Nile, White Nile, Main Nile and Confluences Banks at Tuti Island as summarized in next section.

8:1:1:1 Methods of Stabilizing Blue Nile Banks

The total length of the Blue Nile Banks is 23.250 km. The Blue Nile as specified before is the main driving forces and has direct impact for the stabilization methods that will be applied to Nile Banks due to the hydrology, morphology, geotechnical and general characteristics of the

Blue Nile. Related to those characteristics and banks soil, the Blue Nile Banks as specified in chapter six are stabilized with:

- Concrete Walls Method for River Stop Stations with total length of 1400 m.
- Concrete and Brick Walls Method with total length of 14350 m.
- Timber Wood piling Method for military areas with total length of 3700 m.
- Existing Bricks Walls Method on Shore 3 with total length of 3800 m.

8:1:1:2 Methods of Stabilizing White Nile Banks

The total length of the White Nile Banks is 24500 m. The White Nile is composed of wide shores and of stable flow. Related to the characteristics, hydrology and banks soils of the White Nile their banks as specified in Chapter Six will be stabilized with:

- Raking Bricks Walls Method for River Stop Stations and Fithab Urban Area with total length of 3750 m.
- Masonry on Dry Pitching Earth Embankments with total length of 11850 m.
- Earth Embankments for rural areas with total length of 8900 m.

8:1:1:3 Methods of Stabilizing Main Nile Banks

The total length of the Main Nile Shores is 9750 m. The characteristics, river pattern system, hydrology and banks soils of the Main Nile are similar to the Blue Nile. Therefore the banks of the Main Nile Shores as specified in Chapter Six will be stabilized with:

- Concrete Walls Method for River Stop Stations with total length of 300 m.
- Concrete and Brick Walls Method with total length of 8200 m.
- Existing Bricks Walls Method on Shore 9 with total length of 1250 m.

8:1:1:4 Methods of Stabilizing Confluences Banks

The total length of the Confluences Shores at Tuti Island is 10375 m. These shores as specified in Chapter Six will be stabilized with:

- Concrete Walls Method for River Stop Stations with total length of 400 m.
- Concrete and Brick Walls Method with total length of 9975 m.

8:1:2 Proposed Development Plan for the Nile River Shores

The Proposed Development Plan for SDNRF at Greater Khartoum as second area in this study that tackles the following development and architectural issues:

8:1:2:1 River Traffic System

River Traffic System composed of river routes and their river stop stations as specified in previous chapters. The system as specified composed of 19 river stop stations with different length due to hierarchy and function of that river stations. This system leads to assist traffic and also support water based recreational activities in the study area. The system also creates new urban elements and better utilization of the Nile River in Greater Khartoum.

8:1:2:2 Grey Traffic System

Grey Traffic System is integrated with River Traffic System so as to gain a better traffic system in Greater Khartoum. The system is composed of asphalt roads in a hierarchical way as specified in previous chapter. These integrated traffic systems lead to create better environment and decrease pollution in the study area.

8:1:2:3 Water Based Recreation

Water Based Recreation composed of recreational activities that depend on water as specified in the previous chapter.

8:1:2:4 Infrastructures

Infrastructures in the final version of the proposed development plan for SDNRF at Greater Khartoum composed of sewerage and disposal system, water supply system, drainage system, electricity supply system, telecommunication system, and any others infrastructures that required for the development. These infrastructures should be of those types that familiar to environment

and not caused pollutions to the study area. This issue can be gained by laws, regulations and EIA statements for those development elements.

8:1:2:5 Greenway System

Greenway System as specified in previous chapter composed of main attractive points, sub attractive points and attractive points. The system is supported by those potential areas and the Nile River as main blue way in Greater Khartoum. The Greenway system in the proposed development plan established new urban elements and improve the general environment in the study area.

8:1: 2:6 Cornice

The Cornice as specified before in the proposed development plan for SDNRF at Greater Khartoum in the previous chapter is extended on both sides of the Nile River Shores. The cornice on both sides of the Nile River is connected the different development and recreational elements that will be implemented on the different Nile Shores.

8:1:2:7 Greenway Routes

Greenway Routes in the final version of the proposed development plan for SDNRF at Grater Khartoum composed of vegetations a long the proposed cornice. These vegetations will be integrated with the proposed landscape and various development elements.

8:1:2:8 Footpaths

Footpaths in the final version of the proposed development plan for SDNRF at Greater Khartoum composed of paths and routes beside the cornice for different users and activities.

8:1:2:9 Mix Used Urban Elements

Mix Used Urban Elements in the final version of the proposed development plan for SDNRF at Greater Khartoum composed of different development elements to satisfy the various urban and population needs. These elements will be established due to the formulation and regulation polices that will be applied for the different planning process.

8:1:2:10 Laws and Regulations for SDNRF at Greater Khartoum

Laws and Regulations in the final version of the proposed development plan for SDNRF at Greater Khartoum composed of different laws and regulations that able to control and direct the development elements in the study area. These laws and regulations are specified in the Appendices 2, 3, 4 and 5.

8:1:2:11 SDNRF Manual

SDNRF Manual in the final version of the proposed development plan for SDNRF at Greater Khartoum tackles summary of the two areas of this study so as to increase public awareness about sustainable development of the Nile River Front, which considered one of the most unique area in Greater Khartoum. The SDNRF Manual for the study area is specified in Appendix 6.

The development plan for the Nile River Shores should direct and control the development that will be implemented to those 16 Nile Shores in Greater Khartoum. The development in this valuable area in Greater Khartoum should be formulated according to scientific studies and planning approaches. This study tries to tackle the 16 Nile Shores in the study area and propose stabilization methods and urban elements for them. But now those shores are development with ad hoc planning policy that may cause problems to future generations. The development plan or the Final Version of the Proposed Development Plan for the Sustainable Development of the Nile River Front SDNRF in Greater Khartoum that tackled above architectural issues is illustrated in Fig 8:1.

The final version of the proposed development plan for SDNRF at Greater Khartoum will be evaluated by numerical values of the two areas of the study stabilization methods of the Nile River Banks and sustainable development of the Nile River Shores. The evaluation of sustainable development plan tackles environmental indicators, economic indicators and social indicators. The evaluations of the final version of the proposed development plan for the two areas will be as specified below.

8:2 Evaluations of the Proposed Stabilization Methods for Nile River Banks

The Banks Stabilization Methods evaluated by assessing methods of construction materials that used for stabilizing each type of the Nile River Banks. The assessment of the stabilization methods for each bank of the Nile River Shore will be evaluated from their numerical values or marks due to the method of construction materials that used for it as specified below:

8:2:1 Evaluations of the Proposed Stabilization Methods for the Blue Nile Banks

The Blue Nile Banks as specified in chapter six were stabilized by five methods of stabilization banks in the proposed development plan. Each of these stabilization methods has numerical value or marks due the type of construction materials that used in it as specified below:

(i) Concrete Walls Method = 10 marks

(ii) Concrete and Brick Walls Method = 9 marks

(iii) Brick and/ or Masonry Walls Method = 8 marks

(iv) Timber or Wood Piling Method = 7 marks

(v) None = 0 marks

Based on above numerical values of the stabilization methods used for each of the Blue Nile River Banks, the assessment and evaluations of these methods will be as specified in Table 8-1

Fig 8-1 Proposed of the Final Version Development Plan for the Sustainable Development of the Nile River Front SDNRF at Greater Khartoum (source the author)

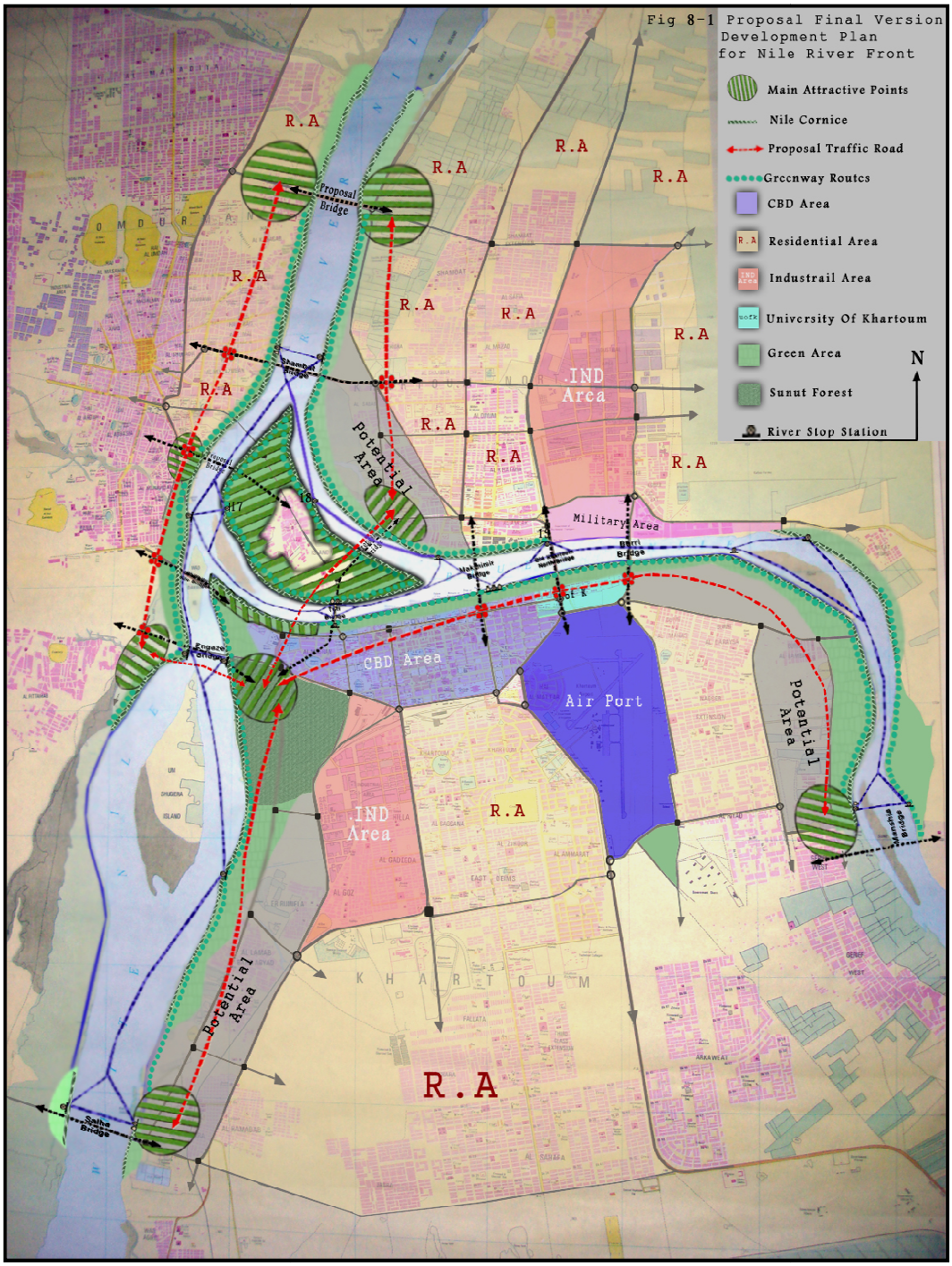


Table 8-1 Evaluations of the Proposed Stabilization Methods for the Blue Nile Banks (source the author)

Shore No	Shore Length in / m	Current Stabilization Method	Proposed Stabilization Methods in/m					Value of the Current Situation	Value of the Proposed Methods	FFull Value or Marks
			Conc. Walls	Conc. & Brick Walls	Brick & Masonry Walls	Timber or Wood Pilling	Non			
1	**3000**	**None**	**500**	**2500**				**0**	**9.20**	**10**
2	**3000**	**None**	**100**	**1200**		**1700**		**0**	**7.90**	**10**
3	**4000**	**Brick Walls**	**200**		**3800 (ex.)**			**7.6**	**0. 50**	**10**
6	**4250**	**None**	**100**	**4150**				**0**	**9.03**	**10**
13	**4500**	**None**	**300**	**4200**				**0**	**9.07**	**10**
14	**4500**	**None**	**200**	**2300**		**2000**		**0**	**8.16**	**10**
Total	**23250**		**1400**	**14350**	**3800**	**3700**		**7.6**	**43.86**	
Total value of current and proposed stabilization methods									**51.46**	**60**

8:2:2 Evaluations of the Proposed Stabilization Methods for the White Nile Banks

The White Nile Banks due to the slow inclination of the banks and stable flow of the river, there are four methods of stabilization banks in the proposed development plan as specified in chapter seven. Each of these stabilization methods has numerical value or marks due the type of construction materials that used in it as specified below:

(i) Masonry and /or brick walls (vertically or racking) = 10 marks
(ii) Masonry on dry pitching earth embankments = 9 marks
(iii) Dry earth embankments = 8 marks
(iv) None = 0 marks

Based on above numerical values, the assessment and evaluations of the stabilization methods that used in stabilizing each of the White Nile Banks will be as summarized in Table 8-2

Table 8-2 Evaluations of the Proposed Stabilization Methods for the White Nile Banks (source the author)

Shore No	Shore Length in / m	Current Stabilization Method	Proposed Stabilization Methods in/m				Value of the Current Situation	Value of the Proposed Methods	Full Value or Marks
			Masonry and / or brick walls	Masonry on dry pitching earth embankment	Dry Earth Embankment	Non			
7	1250	Masonry on dry pitching earth embankment		1250			9		10
8	1250	None	1250					10	10
15	11000	None	400	10600				9.04	10
16	11000	None	2100		8900			8.38	10
Total	24500		3750	11850	8900		9	27.42	
Total value of current and proposed stabilization methods								36.42	40

8:2:3 Evaluations of the Proposed Stabilization Methods for the Main Nile Banks

The stabilization methods of the Main Nile Banks are similar to those methods of the Blue Nile Banks as specified before and with the same numerical values as specified in Table 8-3:

Table 8-3 Evaluations of the Proposed Stabilization Methods for the Main Nile Banks (source the author)

Shore No	Shore Length in / m	Current Stabilization Method	Proposed Stabilization Methods in/m					Value of the Current Situation	Value of the Proposed Methods	Full Value or Marks
			Conc. Walls	Conc. & Brick Walls	Brick & Masonry Walls	Timber or Wood Pilling	Non			
9	3750	Brick & Masonry Walls	100	2400	1250			2.67	6.03	10
11	3000	None	100	2900					9.03	10
12	3000	None	100	2900					9.03	10
Total	9750		300	8200	1250			2.67	24.09	
Total value of current and proposed stabilization methods									26.76	30

8:2:4 Evaluations of the Proposed Stabilization Methods for the Confluences Banks

The Confluences Banks at Tuti Island in the final version of the proposed development plan were stabilized as specified in chapter seven by the similar five methods of stabilizing the Blue Nile Banks. The numerical values and marks of those methods as specified above and their assessment and evaluations for Confluences Banks will be as summarized in Table 8-4.

Table 8-4 Evaluations of the Proposed Stabilization Methods for the Confluences Banks at Tuti Island (source the author)

Shore No	Shore Length in / m	Current Stabilization Method	Proposed Stabilization Methods in/m					Value of the Current Situation	Value of the Proposed Methods	Full Value or Marks
			Conc. Walls	Conc. & Brick Walls	Brick & Masonry Walls	Timber or Wood Pilling	Non			
4	3500	None	200	3300				0	9.06	10
5	3875	None	100	3775				0	9.03	10
10	3000	None	100	2900					9.03	10
Total	10375		400	9975				0	27.12	30

From above tables the total marks of the stabilization methods for the sixteenth Nile River Banks are 141.76 marks (88.6%) from 160 as total marks in the proposed development plan for SDNRF at Greater Khartoum.

8:3 Evaluations of the Proposed Sustainable Development Plan for Nile River Shores

Evaluations of the sustainable development for the Nile River Shores in the final version plan composed of the assessment of environmental, economical and social indicators as specified in below sections:.

8:3:1 Evaluations of Environmental Indicators in the proposed Development Plan for SDNRF at Greater Khartoum

The Environmental Indicators that assessing the final version of the proposed development plan for SDNRF at Greater Khartoum composed of seven types and each type composed of a number of indicators. The assessment and evaluations of these Environmental Indicators will be gained from the summations of their numerical values from the full marks which is 10 marks, as specified below:

(i) Evaluations of Traffic System

Evaluations of Traffic System to Nile River Shores will be according to the numerical values for each method of the traffic system that will be used for each Nile River Shore in the development plan as specified below:

- River traffic System = 5 marks
- Asphalt Streets = 5 marks
- Earth Streets = 3 marks
- None = 0 marks

(ii) Evaluations of Accessibility to Nile River Shore

Accessibility to Nile River Shores will be evaluated and assessed due to the numerical values of the methods of accessibility to them as summarized below:

- Accessibility by River Routes = 5 marks
- Accessibility by Asphalt Streets = 5 marks
- Accessibility by Earth Streets = 3 marks
- No Accessibility = 0 marks

(iii) Evaluations of Flexibility

Flexibility of the elements in the final version of the proposed development plan for SDNRF at Greater Khartoum will be evaluated due to the numerical values of the indicators that measuring degree of flexibility as specified below:

- Continuation of the main Development Elements = 2 marks
- Coherence of the Development Elements = 2 marks
- Zoning of the Development Elements = 2 marks
- Adaptation with local factors = 2 marks
- Degree of changes to better performance = 2 marks

(iv) Evaluations of Greenway System

Evaluations and assessments of the quality of the Greenway System in the final version of the proposed development plan will be obtained from the ten indicators where the numerical value of each indicator = 1 mark. These indicators are main attractive points, sub attractive points, cornice, public parks, recreational elements, cultural elements, footpaths, Blue way system, ecological way system and the mixed used elements.

(v) Evaluations of Sky Line

Evaluations of sky line in the Development Plan will be assessed due to the numerical values of the indicators that measuring the quality of the sky line as specified below:

- Good panoramic view of the Nile River Front = 2 marks.
- Good quality of openness of the Nile River Stream = 2 marks.
- Regular view of building heights along river front = 2 marks.
- Legislations required for the development = 2 marks.
- Regular vegetation types along river front = 2 marks.

(vi) Evaluations of Blue Way of the Nile River

Evaluations of the quality of the Nile River as main Blue Way in the study area will be assessed from the numerical values of the indicators that measuring the quality of the Blue Way in the proposed Development Plan as specified below:

- Environmental Impact Assessment EIA for the Development = 2 marks.
- Pollution Control in the proposed Development Plan = 2 marks.
- Laws and Legislations required for the Development = 2 marks.
- Good Sightseeing of the Nile River = 2 marks.
- Good quality of the River Corridor System = 2 marks

(vii) Evaluations of Improving the General Environment

Evaluation of improving the general environment will be assessed from the numerical values of the five indicators that measuring the quality of the General Environment in the proposed

Development Plan where each indicator = 2marks. These indicators are composed of satisfaction of greenway system, implementation of the development plan, amount of pollution, building regulations and EIA statement for each elements of the development.

The final version of the Proposed Development Plan for SDNRF at Greater Khartoum will be evaluated and assessed by above numerical values of Environmental Indicators for Blue Nile Shores, White Nile Shores, Main Nile Shores and Confluences Shores at Tuti Island as specified below:

8:3:1:1 Evaluations of Environmental Indicators for the Blue Nile Shores

Based on above numerical values of Environmental Indicators the specifications of the evaluations of the environmental situations for the Blue Nile Shores in the proposed development plan are specified in Table 8-5.

Table 8-5 Evaluations of Environmental Indicators for the Blue Nile Shores (source the author)

Environmental Type	Environmental Indicators	Blue Nile Shores Numbers						Prop. Marks	Full Marks
		1	2	3	6	13	14		
Traffic Systems	River Traffic System	5	2.17	5	5	5	2.78	49.9	60
	Asphalt Roads	5	2.17	5	5	5	2.78		
	Earth Streets								
	None								
	Total	10	4.34	10	10	10	5.56		
Accessibility	River Transport	5	2.17	5	5	5	2.78	49.9	60
	Public Asphalt Roads	5	2.17	5	5	5	2.78		
	Public Earth Streets								
	No Accessibility								
	Total	10	4.34	10	10	10	5.56		
Flexibility	Continuation of the Development Elements	2	0.87	2	2	2	1.11	49.9	60
	Coherent of the elements	2	0.87	2	2	2	1.11		
	Zoning of the elements	2	0.87	2	2	2	1.11		
	Adaptation with local factors	2	0.87	2	2	2	1.11		
	Degree of changes to better performance	2	0.87	2	2	2	1.11		
	Total	10	4.35	10	10	10	5.55		
Greenway System	Main attractive points	1	1	1	1	1	1	53.94	60
	Sub attractive points	1	0.43	1	1	1	0.56		
	Cornice	1	0.43	1	1	1	0.56		
	Public parks	1	1	1	1	1	1		
	Recreational elements	1	0.43	1	1	1	0.56		
	Cultural Elements	1	0.43	1	1	1	0.56		
	Footpaths	1	0.43	1	1	1	0.56		

Environmental Type	Environmental Indicators	Blue Nile Shores Numbers						Prop. Marks	Full Marks
		1	2	3	6	13	14		
	Blue Way System	1	1	1	1	1	1		
	Ecological way System	1	1	1	1	1	1		
	Mixed used elements	1	0.43	1		1	0.56		
	Total	10	6.58	10	10	10	7.36		
Sky Line	Panoramic View of the Nile	2	0.87	2	2	2	1.11		
	Degree of openness of the Nile River stream	2	2	2	2	2	2		
	Building Height	2	0.87	2	2	2	1.11	53.94	60
	Legislations	2	2	2	2	2	2		
	Vegetation Types	2	0.87	2	2	2	1.11		
	Total	10	6.61	10	10	10	7.33		
Blue Way of the Nile River	EIA for the Development	2	2	2	2	2	2		
	Pollution Control	2	2	2	2	2	2		
	Laws and Legislations	2	2	2	2	2	2		
	Sightseeing	2	0.87	2	2	2	1.11	57.98	60
	River Corridor System	2	2	2	2	2	2		
	Total	10	8.87	10	10	10	9.11		
Improving of General Environment	Satisfaction of the Greenway System	2	1.31	2	2	2	1.47		
	Implementation of the Development Plan	2	0.87	2	2	2	1.11		
	Amount of Pollution	2	2	2	2	2	2		
	Building Regulations	2	2	2	2	2	2	56.76	60
	Environmental Impact Assessment EIA	2	2	2	2	2	2		
	Total	10	8.18	10	10	10	8.58		
Grand Total		70	43.27	70	70	70	49.05	372. 32	420

8:3:1:2 Evaluations of Environmental Indicators for the White Nile Shores

Based on numerical values of Environmental Indicators, the evaluations and assessment of them for the White Nile Shores in the final version of the proposed development Plan, will be as specified in Table 8-6

Table 8-6 Evaluations of Environmental Indicators for the White Nile Shores (source the author)

Environmental Type	Environmental Indicators	White Nile Shores Numbers				Prop. Marks	Full Marks
		7	8	15	16		
Traffic Systems	River Traffic System	5	5	5	5		
	Asphalt Roads	5	5	5	5		
	Earth Streets					40	40
	None						
	Total	10	10	10	10		
Accessibility	River Transport	5	5	5	5		
	Public Asphalt Roads	5	5	5	5		
	Public Earth Streets					40	40
	No Accessibility						
	Total	10	10	10	10		

Environmental Type	Environmental Indicators	White Nile Shores Numbers				Prop. Marks	Full Marks
		7	8	15	16		
Flexibility	Continuation of the Development Elements	2	2	2	2	36.72	40
	Coherent of the elements	2	2	2	0.36		
	Zoning of the elements	2	2	2	0.36		
	Adaptation with local factors	2	2	2	2		
	Degree of changes to better performance	2	2	2	2		
	Total	10	10	10	6.72		
Greenway System	Main attractive points	1	1	1	1	37.54	40
	Sub attractive points	1	1	1	0.18		
	Cornice	1	1	1	1		
	Public parks	1	1	1	1		
	Recreational elements	1	1	1	1		
	Cultural Elements	1	1	1	1		
	Footpaths	1	1	1	0.18		
	Blue Way System	1	1	1	1		
	Ecological way System	1	1	1	1		
	Mixed used elements	1	1	1	0.18		
	Total	10	10	10	7.54		
Sky Line	Panoramic View of the Nile	2	2	2	2	38.36	40
	Degree of openness of the Nile River	2	2	2	2		
	Building Height	2	2	2	0.36		
	Legislations	2	2	2	2		
	Vegetation Types	2	2	2	2		
	Total	10	10	10	8.36		
Blue Way of the Nile River	EIA Statements	2	2	2	2	38.36	40
	Pollutions	2	2	2	2		
	Laws and Legislations	2	2	2	2		
	Sightseeing	2	2	2	0.36		
	River Corridor System	2	2	2	2		
	Total	10	10	10	8.36		
Improving of General Environment	Satisfaction of Greenway System	2	2	2	1.51	39.51	40
	Implementation of the Development Plan	2	2	2	2		
	Degree of Pollution	2	2	2	2		
	Building Regulations	2	2	2	2		
	Environmental Impact Assessment EIA	2	2	2	2		
	Total	10	10	10	9.51		
Grand Total		70	70	70	60.49	270.49	280

8:3:1:3 Evaluations of Environmental Indicators for the Main Nile Shores

Referring to the numerical values of Environmental Indicators, the assessment of these indicators for the Main Nile Shores in the SDNRF at Greater Khartoum will be as summarized in Table 8-7

Table 8-7 Evaluations of Environmental Indicators for the Main Nile Shores (source the author)

Environmental Type	Environmental Indicators	Main Nile Shores Numbers			Prop. Marks	Full Marks
		9	11	12		
Traffic Systems	River Traffic System	5	5	5	30	30
	Asphalt Roads	5	5	5		
	Earth Streets					
	None					
	Total	10	10	10		
Accessibility	River Transport	5	5	5	30	30
	Public Asphalt Roads	5	5	5		
	Public Earth Streets					
	No Accessibility					
	Total	10	10	10		
Flexibility	Continuation of the Development Elements	2	2	2	30	30
	Coherent of the elements	2	2	2		
	Zoning of the elements	2	2	2		
	Adaptation with local factors	2	2	2		
	Degree of changes to better performance	2	2	2		
	Total	10	10	10		
Greenway System	Main attractive points	1	1	1	30	30
	Sub attractive points	1	1	1		
	Cornice	1	1	1		
	Public parks	1	1	1		
	Recreational elements	1	1	1		
	Cultural Elements	1	1	1		
	Footpaths	1	1	1		
	Blue Way System	1	1	1		
	Ecological way System	1	1	1		
	Mixed used elements	1	1	1		
	Total	10	10	10		
Sky Line	Panoramic View of the Nile	2	2	2	30	30
	Degree of openness of the Nile River	2	2	2		
	Building Height	2	2	2		
	Legislations	2	2	2		
	Vegetation Types	2	2	2		
	Total	10	10	10		
Blue Way of the Nile River	EIA Statements	2	2	2	30	30
	Pollutions	2	2	2		
	Laws and Legislations	2	2	2		
	Sightseeing	2	2	2		
	River Corridor System	2	2	2		
	Total	10	10	10		
Improving of General Environment	Satisfaction of Greenway System	2	2	2	30	30
	Implementation of the Development Plan	2	2	2		
	Degree of Pollution	2	2	2		
	Building Regulations	2	2	2		
	Environmental Impact Assessment EIA	2	2	2		
	Total	10	10	10		
Grand Total		70	70	70	210	210

8:3:1:4 Evaluations of Environmental Indicators for the Confluences Shores

Based on numerical values of Environmental Indicators, the assessment of environmental indicators for the Confluences Shores at Tuti Island in the final version of the proposed development Plan, will be as specified in Table 8-8

Table 8-8 Evaluations of Environmental Indicators for the Confluences Shores (source the author)

Environmental Type	Environmental Indicators	Confluences Shores at Tuti Island			Prop. Marks	Full Marks
		4	5	10		
Traffic Systems	River Traffic System	5	5	5	30	30
	Asphalt Roads	5	5	5		
	Earth Streets					
	None					
	Total	10	10	10		
Accessibility	River Transport	5	5	5	30	30
	Public Asphalt Roads	5	5	5		
	Public Earth Streets					
	No Accessibility					
	Total	10	10	10		
Flexibility	Continuation of the Development Elements	2	2	2	30	30
	Coherent of the elements	2	2	2		
	Zoning of the elements	2	2	2		
	Adaptation with local factors	2	2	2		
	Degree of changes to better performance	2	2	2		
	Total	10	10	10		
Greenway System	Main attractive points	1	1	1	30	30
	Sub attractive points	1	1	1		
	Cornice	1	1	1		
	Public parks	1	1	1		
	Recreational elements	1	1	1		
	Cultural Elements	1	1	1		
	Footpaths	1	1	1		
	Blue Way System	1	1	1		
	Ecological way System	1	1	1		
	Mixed used elements	1	1	1		
	Total	10	10	10		
Sky Line	Panoramic View of the Nile	2	2	2	30	30
	Degree of openness of the Nile River stream	2	2	2		
	Building Height	2	2	2		
	Legislations	2	2	2		
	Vegetation Types	2	2	2		
	Total	10	10	10		
Blue Way of the Nile River	EIA for the Development	2	2	2	30	30
	Pollution Control	2	2	2		
	Laws and Legislations	2	2	2		
	Sightseeing	2	2	2		
	River Corridor System	2	2	2		

Environmental Type	Environmental Indicators	Confluences Shores at Tuti Island			Prop. Marks	Full Marks
		4	5	10		
	Total	10	10	10		
Improving of General Environment	Satisfaction of the Greenway System	2	2	2	30	30
	Implementation of the Development Plan	2	2	2		
	Amount of Pollution	2	2	2		
	Building Regulations	2	2	2		
	Environmental Impact Assessment EIA	2	2	2		
	Total	10	10	10		
Grand Total		70	70	70	210	210

From above tables that assessing the environmental situations from numerical values of environmental indicators in the proposed development plan for SDNRF at Greater Khartoum, we can note the following:

(i) The full marks of the seven environmental indicators for the 16 Shores = 1120 marks

(ii) The total value of environmental indicators in the proposed development plan for SDNRF at Greater Khartoum for the 16 Shores = 1062.81 marks

(iii) The percentage of environmental indicators in the proposed development for SDNRF at Greater Khartoum for the 16 Shores = 95 %

(iv) The total value of environmental indicators for the six Blue Nile Shores = 372.32 marks

(v) The total value of environmental indicators for the four White Nile Shores = 270.49 marks

(vi) The total value of environmental indicators for the three Main Nile Shores = 210 marks

(vii) The total value of environmental indicators for the three Confluences Shores = 210 marks

8:3:2 Evaluations of Economic Indicators in the Proposed Development Plan for SDNRF at Greater Khartoum

Evaluations of Economic Indicators in the final version of the proposed development plan for SDNRF at Greater Khartoum will be obtained from the numerical values or marks of the following economical indicators as specified below:

(i) Evaluations of Increases in Land Values

Evaluations of economic indicators that measuring increase in land values due to the proposed development for SDNRF at Greater Khartoum will be obtained from the numerical values of the following five indicators as specified below:

- Increase in land value per m2 = 2 marks
- Increase in land compensation value = 2 marks
- Increase in land income = 2 marks
- Cost Benefit Analysis for the lands values = 2 marks
- New legislations for the proposed development = 2 marks

(ii) Evaluations of Change of Uses in Lands

Evaluations of economic indicators that measuring changes of uses in lands as a resultant of the proposed development plan for SDNRF at Greater Khartoum will be obtained from the numerical values of the following five indicators as specified below:

- Types of land uses in the proposed development plan = 2 marks
- New infrastructures in the proposed development = 2 marks
- New urban elements in the proposed development = 2 marks
- EIA for the proposed development = 2 marks
- New laws for land development control = 2 marks

(iii) Evaluations of Contributions of the Proposed Development to Local and National Economy

Evaluations of contributions of the proposed development elements to local and national economy as a resultant of the development plan of SDNRF at Greater Khartoum will be obtained from the numerical values of the following five indicators:

- Creation of new jobs = 2 marks
- Increase in total income from the development = 2 marks
- Cost Benefit Analysis for the income from the development = 2 marks
- Optimization in local and national economy = 2 marks

- Creation of new development programmed = 2 marks

Evaluations and assessment of those above economic indicators from their numerical values for the Blue Nile Shores, the Confluences Shores at Tuti Island, the White Nile Shores and the Main Nile Shores will be specified in the below sections.

8:3:2:1 Evaluations of Economic Indicators for the Blue Nile Shores

Based on the above numerical values for the evaluations and assessment of the economic indicators in the proposed development for the six Blue Nile Shores in Greater Khartoum are specified in Table 8-9.

Table 8-9 Evaluations of Economic Indicators for the Blue Nile Shores (source the author)

Economic Type	Economic Indicators	Blue Nile Shores Numbers						Prop. Marks	Full Marks
		1	2	3	6	13	14		
Increase in Land Values	Increase in land values per m2	2	0.87	2	2	2	1.11	51.92	60
	Increase in land compensation	2	0.87	2	2	2	1.11		
	Increase in land income	2	0.87	2	2	2	1.11		
	Cost Benefit Analysis	2	0.87	2	2	2	1.11		
	New Legislations	2	2	2	2	2	2		
	Total	10	5.48	10	10	10	6.44		
Changes of Uses in Lands	Types of land uses	2	0.87	2	2	2	1.11	49.9	60
	New infrastructures	2	0.87	2	2	2	1.11		
	New Urban Elements	2	0.87	2	2	2	1.11		
	EIA for the development	2	0.87	2	2	2	1.11		
	New laws for land development control	2	0.87	2	2	2	1.11		
	Total	10	4.35	10	10	10	5.55		
Contributions to Local and National Economy	Creation of new jobs	2	2	2	2	2	2	55.96	60
	Increase in total Income	2	0.87	2	2	2	1.11		
	Cost Benefit Analysis for the income from development	2	2	2	2	2	2		
	Optimization in local and national economy	2	0.87	2	2	2	1.11		
	Creation of new economic programmed	2	2	2	2	2	2		
	Total	10	7.74	10	10	10	8.22		
Grand Total		30	17.57	30	30	30	20.21	157.78	180

8:3:2:2 Evaluations of Economic Indicators for the White Nile Shores

The assessment of Economic Indicators for the White Nile Shores in the SDNRF at Greater Khartoum will be obtained from their above numerical values as summarized in Table 8-10.

Table 8-10 Evaluations of Economic Indicators for the White Nile Shores (source the author)

Economic Type	Economical Indicators	White Nile Shores Numbers				Prop. Marks	Full Marks
		7	8	15	16		
Increase in Land Values	Increase in land values per m2	2	2	2	0.36	33.44	40
	Increase in land compensation	2	2	2	0.36		
	Increase in land income	2	2	2	0.36		
	Cost Benefit Analysis	2	2	2	0.36		
	New Legislations	2	2	2	2		
	Total	10	10	10	3.44		
Changes of Uses in Lands	Types of land uses	2	2	2	0.36	36.72	40
	New infrastructures	2	2	2	2		
	New Urban Elements	2	2	2	0.36		
	EIA for the development	2	2	2	2		
	New laws for land development control	2	2	2	2		
	Total	10	10	10	6.72		
Contributions to Local and National Economy	Creation of new jobs	2	2	2	2	38.36	40
	Increase in total Income	2	2	2	2		
	Cost Benefit Analysis for the income from development	2	2	2	0.36		
	Optimization in local and national economy	2	2	2	2		
	Creation of new economic programmed	2	2	2	2		
	Total	10	10	10	8.36		
Grand Total		30	30	30	18.52	108.52	120

8:3:2:3 Evaluations of Economic Indicators for the Main Nile Shores

Based on above numerical values of the Economic Indicators that measuring quality of the proposed development for the Main Nile Shores, the assessment and evaluations of them will be as specified in Table 8-11.

Table 8-11 Evaluations of Economic Indicators for the Main Nile Shores (source the author)

Economic Type	Economical Indicators	Main Nile Shores Numbers			Prop. Marks	Full Marks
		9	11	12		
Increase in Land Values	Increase in land values per m2	2	2	2	30	30
	Increase in land compensation	2	2	2		
	Increase in land income	2	2	2		
	Cost Benefit Analysis	2	2	2		
	New Legislations	2	2	2		
	Total	10	10	10		
Changes of Uses in Lands	Types of land uses	2	2	2	30	30
	New infrastructures	2	2	2		
	New Urban Elements	2	2	2		
	EIA for the development	2	2	2		
	New laws for land development control	2	2	2		
	Total	10	10	10		
Contributions to Local and National Economy	Creation of new jobs	2	2	2	30	30
	Increase in total Income	2	2	2		
	Cost Benefit Analysis for the income from development	2	2	2		
	Optimization in local and national economy	2	2	2		
	Creation of new economic programmed	2	2	2		
	Total	10	10	10		
Grand Total		30	30	10	90	90

8:3:2:4 Evaluations of Economic Indicators for the Confluences Shores at Tuti Island

Referring to the numerical values of the above Economical Indicators, the assessment of them for the Confluences Shores at Tuti Island in the SDNRF at Greater Khartoum will be specified in Table 8-12

Table 8-12 Evaluations of Economic Indicators for the Confluences Shores at Tuti Island (source the author)

Economic Type	Economic Indicators	Confluence Shores Numbers at Tuti Island			Prop. Marks	Full Marks
		4	5	10		
Increase in Land Values	Increase in land values per m2	2	2	2	30	30
	Increase in land compensation	2	2	2		
	Increase in land income	2	2	2		
	Cost Benefit Analysis	2	2	2		
	New Legislations	2	2	2		
	Total	10	10	10		
Changes of Uses in Lands	Types of land uses	2	2	2	30	30
	New infrastructures	2	2	2		
	New Urban Elements	2	2	2		
	EIA for the development	2	2	2		
	New laws for land development control	2	2	2		
	Total	10	10	10		
Contributions to Local and National Economy	Creation of new jobs	2	2	2	30	30
	Increase in total Income	2	2	2		
	Cost Benefit Analysis for the income from development	2	2	2		
	Optimization in local and national economy	2	2	2		
	Creation of new economic programmed	2	2	2		
	Total	10	10	10		
Grand Total		30	30	30	90	90

From above tables that assessing the economic situations from the numerical values of economic indicators in the proposed development plan for SDNRF at Greater Khartoum, we can note the following:

(i) The full marks of Economic Indicators for the 16 Shores = 480 marks

(ii) The total value of Economic Indicators in the proposed development plan for SDNRF at Greater Khartoum for the 16 Shores = 446.30 marks

(iii) The percentage of Economic Indicators in the proposed development for SDNRF at Greater Khartoum for the 16 Shores = 93 %

(iv) The total marks of the six Blue Nile Shores = 157.78 marks

(v) The total marks of the four White Nile Shores = 108.52 marks

(vi) The total marks of the three Main Nile Shores = 90 marks

(vii) The total marks of the three Confluences Shores at Tuti Island = 90 marks

8:3:3 Evaluations of Social Indicators in the Proposed Development Plan for SDNRF at Greater Khartoum

Evaluations and assessment of Social Indicators in the final version of the development plan for SDNRF at Greater Khartoum composed of three types and each one composed of a number of variables or indicators. The evaluations of these Social Indicators will be obtained from their numerical values as specified in the below section:

(i) Evaluations of Satisfaction for Population Needs

Evaluations and assessment of the indicators that measuring the degree of satisfaction for the population needs and demands in the proposed development for SDNRF at Greater Khartoum, will be obtained from the numerical values of the following five indicators:

- Estimation of population demands from deficiencies = 2 marks.
- Satisfaction of population requirements in the proposed development = 2 marks.
- Increase in public awareness about Sustainable Development = 2 marks.
- Increase in safety to population and their properties = 2 marks.
- SDNRF Manual = 2 marks.

(ii) Evaluations of Improvement in Social Services

Evaluations of improvement in social services in the proposed development for SDNRF at Greater Khartoum will be gained from the numerical values of the following five indicators as specified below:

- Improvement in traffic system = 2 marks.
- Improvement in public utilities = 2 marks.
- Improvement in drinking and disposal waters = 2 marks.
- EIA for the development elements = 2 marks.
- Policies for improving the general social services = 2 marks.

(iii) Evaluations of Improvement in Social Health

Improvement in social health will be evaluated and assessed from the numerical values of the following five indicators as specified below:

- Increase in health facilities in the proposed development plan = 2 marks.
- New drainage and disposal systems in the development plan = 2 marks.
- Avoidance of pollution in the proposed development plan = 2 marks.
- Improvement in health elements such as food, water, hosing etc = 2 marks.
- EIA for the general social health in the proposed development plan = 2 marks.

Based on above numerical values of social indicators, the assessments and evaluations of the Blue Nile Shores, the Confluences Shores at Tuti Island, the White Nile Shores and the Main Nile Shores will be as specified in the below sections:

8:3:3:1 Evaluations of Social Indicators for the Blue Nile Shores

Based on above numerical values of the Social Indicators in the proposed development plan the assessment and evaluations of the Blue Nile Shores are specified in Table 8-13

Table 8-13 Evaluations of Social Indicators for the Blue Nile Shores (source the author)

Social Type	Social Indicators	Blue Nile Shores Numbers						Prop. Marks	Full Marks
		1	2	3	6	13	14		
Satisfaction of Population Needs	Population Demands	2	0.87	2	2	2	1.11	55.96	60
	Population Requirements	2	0.87	2	2	2	1.11		
	Increase of Public awareness	2	2	2	2	2	2		
	Increase in Safety	2	2	2	2	2	2		
	SDNRF Manual	2	2	2	2	2	2		
	Total	10	7.74	10	10	10	8.22		
Improvement in Social Services	Improvement in traffic system	2	2	2	2	2	2	53.94	60
	Improvement in public utilities	2	0.87	2	2	2	1.11		
	Improvement in drinking and disposal waters	2	0.87	2	2	2	1.11		
	EIA for the development	2	2	2	2	2	2		
	Policies for improving the general social services	2	0.87	2	2	2	1.11		
	Total	10	6.61	10	10	10	7.33		
Improvement in Social Health	Increase in health facilities	2	2	2	2	2	2	55.96	60
	New drainage & disposal system	2	0.87	2	2	2	1.11		
	Avoidance of pollution	2	2	2	2	2	2		
	Improvement in health elements	2	0.87	2	2	2	1.11		
	EIA for general social health	2	2	2	2	2	2		
	Total	10	7.74	10	10	10	8.22		
Grand Total		30	22.09	30	30	30	23.77	165.86	180

8:3:3:2 Evaluations of Social Indicators for the White Nile Shores

Based on above numerical values of Social Indicators in the final version of the proposed development plan for SDNRF at Greater Khartoum, the assessment and evaluations of the White Nile Shores are specified in Table 8-14.

Table 8-14 Evaluations of Social Indicators for the White Nile Shores (source the author)

Social Type	Social Indicators	White Nile Shores Numbers				Prop. Marks	Full Marks
		7	8	15	16		
Satisfaction of Population Needs	Population Demands	2	2	2	0.36	35.08	40
	Population Requirements	2	2	2	0.36		
	Increase of Public awareness	2	2	2	2		
	Increase in Safety	2	2	2	0.36		
	SDNRF Manual	2	2	2	2		
	Total	10	10	10	5.08		
Improvement in Social Services	Improvement in traffic system	2	2	2	2	36.72	40
	Improvement in public utilities	2	2	2	0.36		
	Improvement in drinking and disposal waters	2	2	2	0.36		
	EIA for the development	2	2	2	2		
	Policies for improving the general social services	2	2	2	2		
	Total	10	10	10	6.72		
Improvement in Social Health	Increase in health facilities	2	2	2	2	38.36	40
	New drainage and disposal system	2	2	2	0.36		
	Avoidance of pollution	2	2	2	2		
	Improvement in health elements	2	2	2	2		
	EIA for general social health	2	2	2	2		
	Total	10	10	10	8.36		
Grand Total		30	30	30	20.16	110.16	120

8:3:3:3 Evaluations of Social Indicators for the Main Nile Shores

Referring to the above numerical values of Social Indicators, the evaluations and assessment of the Main Nile Shores in the proposed development plan in the SDNRF at Greater Khartoum are specified in Table 8-15.

Table 8-15 Evaluations of Social Indicators for the Main Nile Shores (source the author)

Social Type	Social Indicators	Main Nile Shores Numbers			Prop. Marks	Full Marks
		9	11	12		
Satisfaction of Population Needs	Population Demands	2	2	2	40	30
	Population Requirements	2	2	2		
	Increase of Public awareness	2	2	2		
	Increase in Safety	2	2	2		
	SDNRF Manual	2	2	2		
	Total	10	10	10		
Improvement in Social Services	Improvement in traffic system	2	2	2	40	30
	Improvement in public utilities	2	2	2		
	Improvement in drinking and disposal waters	2	2	2		
	EIA for the development	2	2	2		
	Policies for improving the general social services	2	2	2		
	Total	10	10	10		
Improvement in Social Health	Increase in health facilities	2	2	2	40	30
	New drainage and disposal system	2	2	2		
	Avoidance of pollution	2	2	2		
	Improvement in health elements	2	2	2		
	EIA for general social health	2	2	2		
	Total	10	10	10		
Grand Total		30	30	30	90	90

8:3:3:4 Evaluations of Social Indicators for the Confluences Shores at Tuti Island

Referring to the above numerical values of social indicators, the evaluations of the Confluences Shores at Tuti Island are specified in Table 8-16.

Table 8-16 Evaluations of Social Indicators for the Confluences Shores at Tuti Island (source the author)

Social Type	Social Indicators	Confluences Shores Numbers at Tuti Island			Prop. Marks	Full Marks
		4	5	10		
Satisfaction of Population Needs	Population Demands	2	2	2	30	30
	Population Requirements	2	2	2		
	Increase of Public awareness	2	2	2		
	Increase in Safety	2	2	2		
	SDNRF Manual	2	2	2		
	Total	10	10	10		
Improvement in Social Services	Improvement in traffic system	2	2	2	30	30
	Improvement in public utilities	2	2	2		
	Improvement in drinking and disposal waters	2	2	2		
	EIA for the development	2	2	2		
	Policies for improving the general social services	2	2	2		
	Total	10	10	10		
Improvement in Social Health	Increase in health facilities	2	2	2	30	30
	New drainage and disposal system	2	2	2		
	Avoidance of pollution	2	2	2		
	Improvement in health elements	2	2	2		
	EIA for general social health	2	2	2		
	Total	10	10	10		
Grand Total		30	30	30	90	90

From above Tables 8-13 to 8-16 that assessing the social situations from the numerical values of Social Indicators in the proposed development plan for SDNRF at Greater Khartoum, we can note the following:

(i) The full marks of Social Indicators SI for the 16 Shores = 480 marks

(vii) The total value or marks of SI for the 16 Shores = 456.02 marks

(viii) The percentage of Social Indicators in the proposed development for SDNRF at Greater Khartoum for the 16 Shores = 95 %

(ix) The total marks for the six Blue Nile Shores = 165.86 marks

(x) The total marks of the four White Nile Shores = 110.16 marks

(xi) The total marks of the three Main Nile Shores = 90 marks

(xii) The total marks of the three Confluences Shores at Tuti Island = 90 marks

8:4 Summary of Chapter Eight

Chapter eight specified the final version of the proposed development plan for SDNRF at Greater Khartoum. The plan specified the urban development elements for the sixteenth Nile River Shores the six Blue Nile Shores, the four White Nile Shores, the three Main Nile Shores and the three Confluences Shores at Tuti Island. The development plan illustrates traffic system through the Nile River, Grey System, Greenway System, zoning of the different development elements, potential areas, cornice along Nile River Front, infrastructures and mix used urban elements. The chapter evaluated the stabilization methods for the Nile River Banks in the final version of the proposed development plan based on numerical values of the type of construction materials that used for each stabilization method. The total value for these methods of stabilization banks for the 16^{th} shores is 141.68 where the total summation of them is 160 marks. The chapter evaluated the main elements of sustainability environmental indicators, economic indicators and social indicators in the proposed development plan. The environmental situations in the proposed development plan for SDNRF at Greater Khartoum evaluated from the numerical values of the environmental indicators. The total value of the environmental indicators for the 16^{th} Nile River Shores in the proposed development is 1062.81 marks from the 1120 as full marks. The economic situations in the proposed development for SDNRF at Greater Khartoum evaluated

from the numerical values of the economic indicators. The total value of the economic indicators for the 16th Nile Shores in the proposed development is 446.3 marks from the 480 as full marks. The social situations in the proposed development plan for SDNRF at Greater Khartoum evaluated from the numerical values of the social indicators. The total value of the social indicators for the 16th Nile River Shores in the proposed development plan is 456.02 marks from the 480 as full marks. The total marks of sustainable indicators in the final version of the proposed development plan for SDNRF at Greater Khartoum are 2106.89 marks from the 2240 as full marks which represent 94%.

CHAPTER NINE: SUMMARY AND CONCLUSIONS

9:0 Introduction

This chapter based on previous chapters will specify summary and conclusions of this research. The summary will tackle the two areas of the study area that related to; the stabilization methods for each Nile Banks and the main proposal development issues that required for developing each Nile River Shore in Greater Khartoum. The chapter will summarize the specifications and hydrology of the Nile River. The chapter also will summarize the general characteristics of the study area as derived from previous chapters where there are six frontages for this unique study area. The Blue Nile has two frontages; one is facing Khartoum and the other is facing Khartoum North. The two frontages of the White Nile are facing Khartoum and Omdurman, while the two frontages of the Main Nile are facing Omdurman and Khartoum North. The chapter will specify the characteristics of these six frontages and their divisions to 16 shores and riverfronts along these shores in Greater Khartoum. The chapter will make categorization and summarization for the shores on the; Blue Nile, White Nile, Main Nile and confluences at Tuti Island as specified below:

- **Summary of Development of the Blue Nile River Shores**

The chapter will specify the current situations for the six shores 1, 2, 3, 6, 13 and 14. The chapter will specify the proposal methods for stabilizing Blue Nile Banks and the proposal development elements for each shore on the Blue Nile in Greater Khartoum.

- **Summary of Development of the White Nile River Shores**

The chapter will specify the characteristics and the current situations of the four shores 7, 8, 15 and 16. The four shores are characterized by wide range shore due to the stable discharge flow of the White Nile. The chapter will specify the main issues that required for developing those four shores and the suitable methods for stabilizing them.

- **Summary of Development of the Main Nile River Shores**

The chapter will specify the current situation of the three shores 9, 11 facing Omdurman and 12 facing Khartoum North. The chapter will summarize the suitable proposal stabilization methods for each shore bank and the development elements that required for developing each Nile Shore.

- **Summary of Development of the Confluences Shores at Tuti Island**

There are three shores around Tuti Island facing Khartoum, Khartoum North and Omdurman. The chapter will specify the summarization of the current situation for those shores and development issues that required for sustainable development in the study area.

- **Summary of Development of the Potential Shores**

The chapter will specify the main development issues for the three potential shores in the study area. These shores are one on the Blue Nile, one on the White Nile and one on the Main Nile as sample of proposal development elements for each shore in the study area.

9-1 Hydrology and specifications of the Nile River in the Study Area

The Nile River is an alluvial meandering river and it is considered as a longest river in world with total length of 4145 miles. The Blue and White Nile are merge at Khartoum forming the Main Nile. The Blue Nile is a main driving force that affects the mechanism of the Nile River in our study area that is due to its fluctuation discharge flow in flood and dry season. The hydrology and specifications of the Blue, White and Main Nile River are summarized in Table 9-1.

Table 9-1 Hydrology and Specifications of the Nile River in Greater Khartoum

Specifications	Blue Nile	White Nile	Main Nile	Confluences Area
Discharge Flow in Flood Season	700 M m3 / day	73 M m3/day	773 M m3/day	773 M m3/day
Discharge Flow in Flood Season	10 M m3/day	73 Mm3/day	83 Mm3/day	83 M m3/day
Maximum Water Level	380.88 m a SL	380.66 m a SL	376.88 m a SL	Average 379.40 m
Minimum Water Level	373.06 m a SL	373.21 m a SL	368.82 m a SL	Average 371.60
Variation Level	7.82 m	7.45 m	8.06 m	Average 7.8 m
Width of Main Stream	420 m	1800 m	700 m	The Left Blue Nile Branch width is 246 m and 481 m is the Right Branch
Banks Soils	Clay, Clay Loam and Sandy Clay Loam	Sandy Clay and Sandy Clay Loam	Clay Loam	Clay and Sandy Clay Loam
Total Floodplain Area	490 acres	1493 acres	340 acres	720 acres
No of Shores	6	4	3	3
Total Shores Length	23.250 km	24.500 km	9.750 km	10.375 km
Total Asphalt Roads	9.5 km	None	5.250 km	None
Total Stabilization Banks	4000 m	1250	1250 m	None
Types of Land Uses	Agriculture, Industrial Bricks, Residential, Mixed Used, Governmental and Commercial	Agriculture, Residential, Mixed Used, Governmental and Commercial	Agriculture, Industrial Bricks, Residential, Mixed Used, Governmental and Commercial	Agriculture, Industrial Bricks, Residential, Mixed Used, Governmental and Commercial

9:2 Divisions of the Study Area

Greater Khartoum composed of three cities with total population of 5,274,321 as in the last census carried in 2008. The total population of Khartoum is 1,582,027; Khartoum North is 1,476,964 while Omdurman is 2,215,330. Greater Khartoum is located on the confluences of the Nile River where the Blue Nile and White Nile are emerged forming the Main Nile. This situation as unique location lead to let each of the three cities has two frontages where; Khartoum is facing Blue and White Nile, Khartoum North is facing Blue and Main Nile while Omdurman is facing White and Main Nile.

The study divided those six frontages to sixteenth shores and riverfronts adjacent to those divided shores. The specifications, lengths and locations of the sixteenth shores and their riverfronts adjacent to them are specified in Table 9-2

Table 9-2 Divisions of the Study Area

Shore No	River Name	Facing City	Length/ m	Location
1	Blue Nile	Khartoum	3,000	From Burri Bridge to Mak Nimir Bridge on the Left Side.
2	Blue Nile	Khartoum North	3,000	From Burri Bridge to Mak Nimir Bridge on the Right Side.
3	Blue Nile	Khartoum	4,000	From Mak Nimir Bridge to Old White Nile Bridge on the Left Side.
4	Confluence Left Blue Nile Branch	Tuti Island Facing Khartoum	3,500	From Eastern Side to the Southern Side of Tuti Island.
5	Confluence Right Blue Nile Branch	Tuti Island Facing Khartoum North	3,875	From Eastern Side to the Northern Side of Tuti Island.
6	Blue Nile	Khartoum North	4,250	From Mak Nimir Bridge to Shambat Bridge
7	White Nile	Khartoum	1,250	From Old White Nile Bridge to Engaze Bridge on the Right Side.
8	White Nile	Omdurman	1,250	From Old White Nile Bridge to Engaze Bridge on the Left Side.
9	Main Nile	Omdurman	3,750	From Old White Nile Bridge to Shambat Bridge on the Left Side.

10	**Confluence Main Nile**	**Tuti Island Facing Omdurman**	**3,000**	**From Southern Side to the Northern Side of Tuti Island.**
11	**Main Nile**	**Khartoum North**	**3,000**	**From Shambat Bridge to University of Khartoum Agriculture College on the Right Side.**
12	**Main Nile**	**Omdurman**	**3,000**	**From Shambat Bridge to University of Khartoum Agriculture College on the Left Side.**
13	**Blue Nile**	**Khartoum**	**4,500**	**From Burri Bridge to Manshia Bridge on the Left Side.**
14	**Blue Nile**	**Khartoum North**	**4,500**	**From Burri Bridge to Manshia Bridge on the Right Side.**
15	**White Nile**	**Khartoum**	**11,000**	**From Engaze Bridge to Salha Bridge on the Right Side.**
16	**White Nile**	**Omdurman**	**11,000**	**From Engaze Bridge to Salha Bridge on the Left Side.**

9:3 Development of the Blue Nile River Shores

Summary of development for the six Blue Nile Shores and Riverfronts adjacent to them that facing Khartoum and Khartoum North with total length of 23.250 km will be as specified in Table 9-3

Table 9-3 Summary of development of the Blue Nile River Shores and their Riverfronts

SD Types	**SD Elements**	**Blue Nile Shores**					
		1	**2**	**3**	**6**	**13**	**14**
Current Situations	Shore Length in (m)	3000	3000	4000	4250	4500	4500
	Stabilization Methods of the River Banks	None	None	Masonry and Brick Walls	None	None	None
	Recreation Elements	None	None	3 Public Park Theatre & Cinema at FSH	None	None	None
	River Activities	Boats Club	None	None	None	None	None
	River Sport	None	None	None	None	None	None
	Asphalt Road	3000	None	4000	None	2500	None
	Flood Plain Area	40 acres			100 acres	150 acres	200 acres

SD Types	SD Elements	Blue Nile Shores					
		1	**2**	**3**	**6**	**13**	**14**
	Main Activities	Governmental Educational Agricultural Industrial in Local Mud Brick	Military Area Residential	Governmental Recreational Commercial Mixed Used	Recreational (Friendship Hotel) Agricultural Industrial in Local Mud Brick Residential	Agricultural Industrial in Local Mud Brick Residential	Agricultural Industrial in Local Mud Brick Residential Military Area
Proposed Methods of Stabilization Nile River Banks	Conc. Walls	500	100	200	100	200	100
	Conc. & Brick Walls	2500	1200		4150	4300	2400
	Brick or Masonry Walls			3800			
	Timber Pilling		1700				2000
	Masonry and/or Brick Walls						
	Masonry on dry Pitching						
	Earth Embankments						
	None						
Proposed River Traffic System	Asphalt Roads	3000	1300	4000	4250	4500	2500
	River Stop St.	No 1	No 19	No2	No4	No5 &6	No7&8
	River Sport St	No 1		No2	No4	No6	No7
	River Trip St	No 1		No2	No4	No6	No7
Proposed Greenway System	Footpaths	3000	1300	4000	4250	4500	2500
	Main Park	1		1	1	1	1
	Theme Park	1		3	1	2	1
	Sub Park	2	1	4	2	3	1
	Cornice Length	3000	1300	4000	4250	4500	2500
	Landscape Elements	Different Elements	Different Elements	Different Elements	Different Elements	Different Elements	Different Elements
Proposed Infrastructure	Tramway	3000	1300	4000	4250	4500	2500
	Asphalt Street	3000	1300	4000	4250	4500	2500
	Telecommunications System	Modern System	Modern System	Modern System	Modern System	Modern System	Modern System
	Electricity	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power
	Disposal System	Sewer & Refuse	Sewer & Refuse	Sewer & Refuse	Sewer & Refuse	Sewer & Refuse	Sewer & Refuse

SD Types	SD Elements	Blue Nile Shores					
		1	**2**	**3**	**6**	**13**	**14**
		Disposal	Disposal	Disposal	Disposal	Disposal	Disposal
	Water Supply	Main Station	Sub Station	Main Station	Sub Station	Main Station	Sub Station
Proposed Laws and Regulations	Land Laws	Appendix 2	Appendix 2	Appendix 2	Appendix 2	Appendix 2	Appendix 2
	Building Regulations	Appendix 3	Appendix 3	Appendix 3	Appendix 3	Appendix 3	Appendix 3
	Building Standards	Appendix 4	Appendix 4	Appendix 4	Appendix 4	Appendix 4	Appendix 4
	Planning Regulations	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels
	E I A Statements	Appendix 5	Appendix 5	Appendix 5	Appendix 5	Appendix 5	Appendix 5
	SDNRF Manual	Appendix 6	Appendix 6	Appendix 6	Appendix 6	Appendix 6	Appendix 6

9:4 Development of the White Nile River Shores

Summary of development of the White Nile River Shores that facing Khartoum and Omdurman with total length of 24.500 Km as specified in this study will be summarized in Table 9-4

Table 9-4 Summary of Development of the White Nile River Shores

SD Types	SD Elements	White Nile Shores			
		7	**8**	**15**	**16**
Current Situations	Shore Length in (m)	1250	1250	11000	11000
	Stabilization Methods of the River Banks	Dry Pitching on Earth Embankment	None	None	None
	Recreation Elements	None	None	None	None
	River Activities	None	None	None	None
	River Sport	None	None	None	None
	Asphalt Road in (Km)	None	None	None	None
	Flood Plain Area	145 acres	88 acres	360 acres	900 acres

SD Types	SD Elements	White Nile Shores			
		7	**8**	**15**	**16**
	Main Land Uses & Activities	Under Construction for New CBD Activities	Agricultural Residential Main Military Hospital	Agricultural Residential Governmental (Military Activities)	Agricultural Residential Rural Settlements
Proposed Methods of Stabilization Nile River Banks	Conc. Walls				
	Conc. & Brick Walls				
	Brick or Masonry Walls				
	Timber Pilling				
	Masonry and/or Brick Walls		1250	300	2000
	Masonry on dry Pitching	1250		10700	
	Dry Earth Embankments				9000
	None				
Proposed River Traffic System	Asphalt Roads	1250	1250	11000	2000
	River Stop Stations			No 10,11,12	No 9,13
	River Sport Stations			No 10,12	No 9,13
	River Trip Stations			No 12	No 13
Proposed Greenway System	Footpaths	1250	1250	5000	2000
	Main Park	1	1	2	1
	Theme Park	1	1	3	1
	Sub Park	2	2	4	2
	Cornice Length	1250	1250	5000	2000
	Landscape Elements	Different Elements	Different Elements	Different Elements	Different Elements
Proposed Infrastructure	Tramway	1250	1250	11000	2000
	Asphalt Street	1250	1250	11000	2000
	Telecommunications System	Modern System	Modern System	Modern System	Modern System

SD Types	SD Elements	White Nile Shores			
		7	**8**	**15**	**16**
	Electricity	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power
	Disposal System	Sewer & Refuse Disposal	Sewer & Refuse Disposal	Sewer & Refuse Disposal	Sewer & Refuse Disposal
	Water Supply	Main Station	Main Station	2 Main Stations	2 Main Stations
Proposed Laws and Regulations	Land Laws	Appendix 2	Appendix 2	Appendix 2	Appendix 2
	Building Regulations	Appendix 3	Appendix 3	Appendix 3	Appendix 3
	Building Standards	Appendix 4	Appendix 4	Appendix 4	Appendix 4
	Planning Regulations	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels
	E I A Statements	Appendix 5	Appendix 5	Appendix 5	Appendix 5
	SDNRF Manual	Appendix 6	Appendix 6	Appendix 6	Appendix 6

9:5 Development of the Main Nile River Shores

Summary of development for the three Main Nile River Shores facing Omdurman and Khartoum North with total length of 9.750 km will be as specified in Table 9-5

Table 9-5 Summary of development of the Main Nile River Shores

SD Types	SD Elements	Main Nile Shore		
		9	**11**	**12**
Current Situations	Shore Length in (m)	3750	3000	3000
	Stabilization Methods of the River Banks	1250 Brick or Masonry Walls and 2500 without stabilization	None	None
	Recreation Elements	3 Theme Parks	None	None
	River Activities	None	None	None
	River Sport	None	None	None
	Asphalt Road	3.75	None	1. 5
	Flood Plain Area	70 acres	200 acres	70 acres

SD Types	SD Elements	Main Nile Shore		
		9	**11**	**12**
	Main Activities	Theme Parks Residential Agricultural Mixed Use Activities	Agricultural Industrial in Local Mud Brick Residential	Agricultural Industrial in Local Mud Brick Residential
Proposed Methods of Stabilization Nile River Banks	Conc. Walls	100	100	100
	Conc. & Brick Walls	2400	2900	2900
	Brick or Masonry Walls	1250		
	Timber Pilling			
	Masonry and/or Brick Walls			
	Masonry on dry Pitching			
	Dry Earth Embankments			
	None			
Proposed River Traffic System	Asphalt Roads	3750	3000	3000
	River Stop Stations.	No 14	No 16	No 15
	River Sport Stations	No 14	No 16	No 15
	River Trip Stations	No 14	No 16	No 15
Proposed Greenway System	Footpaths	3750	3000	3000
	Main Park	2	1	1
	Theme Park	3	1	1
	Sub Park	4	1	1
	Cornice Length	3750	3000	3000
	Landscape Elements	Different Elements	Different Elements	Different Elements
Proposed Infrastructure	Tramway	3750	3000	3000
	Asphalt Street	3750	3000	3000
	Telecommunications System	Modern System	Modern System	Modern System
	Electricity	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power
	Disposal System	Sewer & Refuse Disposal	Sewer & Refuse Disposal	Sewer & Refuse Disposal
	Water Supply	Main Station	Main Station	Main Station
Pro	Land Laws	Appendix 2	Appendix 2	Appendix 2

SD Types	SD Elements	Main Nile Shore		
		9	**11**	**12**
	Building Regulations	Appendix 3	Appendix 3	Appendix 3
	Building Standards	Appendix 4	Appendix 4	Appendix 4
	Planning Regulations	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels
	E I A Statements	Appendix 5	Appendix 5	Appendix 5
	SDNRF Manual	Appendix 6	Appendix 6	Appendix 6

9:6 Development of the Confluences Shores at Tuti Island

Summary for development of the Left and Right Branches of the Blue Nile Shores and the Main Nile Shore around Tuti-Island with total length of 10.375 Km as specified in this study will be in Table 9:6

Table 9-6 Summary of development of the Nile River Shores facing Tuti-Island

SD Types	SD Elements	Left Blue Nile Branch Shore	Right Blue Nile Branch Shore	Main Nile Shore
		4	**5**	**10**
Current Situations	Shore Length in (m)	3500	3875	3000
	Stabilization Methods of the River Banks	None	None	None
	Recreation Elements	None	None	None
	River Activities	None	None	None
	River Sport	None	None	None
	Asphalt Road	None	None	None
	Flood Plain Area	Total Area = 720 acres		
	Main Activities	Agricultural Industrial in Local Mud Brick Residential	Agricultural Industrial in Local Mud Brick & Residential	Agricultural Industrial in Local Mud Brick &Residential

SD Types	SD Elements	Left Blue Nile Branch Shore	Right Blue Nile Branch Shore	Main Nile Shore
		4	5	10
Proposed Methods of Stabilization Nile River Banks	Conc. Walls	200	100	100
	Conc. & Brick Walls	3300	3775	2900
	Brick or Masonry Walls			
	Timber Pilling			
	Masonry and/or Brick Walls			
	Masonry on dry Pitching			
	Dry Earth Embankments			
	None			
Proposed River Traffic System	Asphalt Roads	3500	3875	3000
	River Stop Stations.	No3	No18	No 17
	River Sport Stations	No3		
	River Trip Stations	No3		
Proposed Greenway System	Footpaths	3500	3875	3000
	Main Park	1		1
	Theme Park	2		1
	Sub Park	2	1	1
	Cornice Length	3500	3875	3000
	Landscape Elements	Different Elements	Different Elements	Different Elements
Proposed Infrastructure	Tramway	3500	3875	3000
	Asphalt Street	3500	3875	3000
	Telecommunications System	Modern System	Modern System	Modern System
	Electricity	Solar &Hydro power	Solar &Hydro power	Solar &Hydro power
	Disposal System	Sewer & Refuse Disposal	Sewer & Refuse Disposal	Sewer & Refuse Disposal
	Water Supply	Main Station	Sub Station	Main Station
Proposed Laws and Regulations	Land Laws	Appendix 2	Appendix 2	Appendix 2
	Building Regulations	Appendix 3	Appendix 3	Appendix 3
	Building Standards	Appendix 4	Appendix 4	Appendix 4
	Planning Regulations	National, Regional & Local Levels	National, Regional & Local Levels	National, Regional & Local Levels
	E I A Statements	Appendix 5	Appendix 5	Appendix 5

SD Types	SD Elements	Left Blue Nile Branch Shore	Right Blue Nile Branch Shore	Main Nile Shore
		4	**5**	**10**
	SDNRF Manual	Appendix 6	Appendix 6	Appendix 6

9:7 Summary of Proposal Development of Potential Shore 1 on the Blue Nile

Shore 1 and its adjacent riverfront is located near the main CBD area in Greater Khartoum on the left side of the Blue Nile facing Khartoum. The shore is facing important and historical building in Khartoum such as; the public governmental palace, University of Khartoum (Gordon College), the main Boats Sport Club, the Blue Nile Cinema, Ministry of Irrigation, Ministry of Health and the main resident for the University of Khartoum. The total shore length is 3,000 m where the bank of this shore in the proposal development plan is stabilized by; concrete walls method with total length of 500 m and the remaining which is 2,500 m is stabilized concrete and brick walls method. The main development elements in the proposal development plan are summarized in Table 9-7.

Table 9-7 Summary of the main Proposal Development Elements on Shore 1

SD Types	SD Elements	No	Length along Shore/ m	Area / Acre and Specifications
Traffic & Service System	Asphalt Street		3,000	Along Riverfront
	Tram Line		3,000	Along Riverfront
	River Traffic Method		3,000	Main Stream
	Cars Parking Area		500	2.5
	Main Water Supply Pipe Line		3,000	Along Riverfront
	Main Sewerage and Disposal System		3,000	Along Riverfront
	Main Electric Supply Cables and Lines		3,000	Along Riverfront
Stabilization Methods	Concrete Walls Method	1	500	Along River Bank
	Concrete and Bricks Walls Method	1	2,500	Along River bank
Water Based Recreation	Water Sports		500	Beside the Main River Sport Station along the Concrete Walls.
	Cruisers			
	Floating Nile Restaurants			
	Fishing			
	Water Based Urban Activities			
Main Cornice	Footpaths		3,000	Along River Bank
	Walkways			
	Service Points			
Greenway Routes	Main Landscapes Elements	7	3,000	Along Cornice
	Vegetations			
	Fountains			
	Sculptures			
	Sub Landscapes Elements			
Parks	Main Park	1	1,000	13
	Theme Park	1	400	5
	Sub Parks	2	Each 200	Each 2.5
Mix Used Central Services	Commercial Areas		700	9
	Specialized Recreational Areas			
	Health Services Areas			
	Specialized Services Areas			
	Mixed Used Elements			

9:8 Summary of Proposal Development of Potential Shore 8 on the White Nile

Shore 8 and its adjacent riverfront are located on the White Nile facing Omdurman with total length of 1,250 m. It is extended from the Old White Nile Bridge to Engaze Bridge near Omdurman CBD area and facing the new CBD area for Africa along Shore 7 in Khartoum. The shore bank in the proposal development plan is stabilized with raking brick walls method. The main proposal urban elements in the proposal plan are summarized in Table 9-8.

Table 9-8 Summary of the main Proposal Development Elements on Shore 8

SD Types	SD Elements	No	Length along Shore/ m	Area/Acre and Specifications
Traffic & Service System	Asphalt Street		1,250	Along Riverfront
	Tram Line		1,250	Along Riverfront
	River Traffic Method		1,250	Main Stream
	Cars Parking Area		400	3
	Main Water Supply Pipe Line		1,250	Along Riverfront
	Main Sewerage and Disposal System		1,250	Along Riverfront
	Main Electric Supply Cables and Lines		1,250	Along Riverfront
Stabilization Methods	Raking Bricks and/ or Masonry Walls Method	1	1,250	Along River Bank
Water Based Recreation	Water Sports		1,250	Beside the raking bricks walls along the wide shore bank of the White Nile
	Cruisers			
	Floating Nile Restaurants			
	Fishing			
	Water Based Urban Activities			
Main Cornice	Footpaths		1,250	Along River Bank
	Walkways			
	Service Points			
Greenway Routes	Main Landscapes Elements	12	1,250	Along Cornice
	Vegetations			
	Fountains			
	Sculptures			
	Sub Landscapes Elements			
Parks	Main Park	1	350	15
	Theme Park	1	200	8
	Sub Parks	2	Each 150	Each 5

Mix Used Central Services	Commercial Areas		400	20
	Specialized Recreational Areas			
	Health Services Areas			
	Specialized Services Areas			
	Mixed Used Elements			

9:9 Summary of Proposal Development of Potential Shore 9 on the Main Nile

Shore 9 is located near Omdurman CBD area on the left side of the Main Nile facing Omdurman. It is extended from Old White Nile Bridge to Shambat Bridge. The shore is facing most of important buildings in Grater Khartoum such as; the main Sudan television centre, the main theatre in Greater Khartoum, the main Sudan Radio Station, Omdurman main Parks, Sudan Parliament Building and Mahdiya Historical Buildings. The total shore length is 3,750 m where part of this shore is stabilized with Brick Walls Method of total length of 1,250 m. The remaining bank of this shore in the proposal development plan is stabilized by; concrete walls method with total length of 100 m for River Stop Station and the remaining which is 2,400 m is stabilized with concrete and brick walls method. The main development elements in the proposal development plan for this potential shore are summarized in Table 9-9.

Table 9-9 Summary of the main Proposal Development Elements on Shore 9

SD Types	**SD Elements**	**No**	**Length along Shore/ m**	**Area / Acre and Specifications**
Traffic & Service System	Asphalt Street		3,750	Along Riverfront
	Tram Line		3,750	Along Riverfront
	River Traffic Method		3,750	Main Stream
	Cars Parking Area		500	3
	Main Water Supply Pipe Line		3,750	Along Riverfront
	Main Sewerage and Disposal System		3,750	Along Riverfront
	Main Electric Supply Cables and Lines		3,750	Along Riverfront
Stabilization Methods	Bricks and/ or Masonry Walls Method	1	1,250	Along River Bank

Water Based Recreation	Concrete Walls Method	1	100	Beside the concrete walls near the River Stop Station No 14
	Concrete and Brick Walls Method	1	2,400	
	Water Sports		3,750	
Main Cornice	Cruisers		3,750	Along River Bank
	Floating Nile Restaurants			
	Fishing			
	Water Based Urban Activities			
	Footpaths			
Greenway Routes	Walkways		3,750	Along Cornice
	Service Points			
	Main Landscapes Elements	27		
Parks	Vegetations		Each 500	Each 8
	Fountains			
	Sculptures			
	Sub Landscapes Elements			
	Main Park	2		
Mix Used Central Services	Theme Park	3	Each 300	Each 4
	Sub Parks	4	Each 200	Each 2
	Commercial Areas	2	Each 750	Each 12
	Specialized Recreational Areas			
	Health Services Areas			
	Specialized Services Areas			
	Mixed Used Elements			

9-10 Summary of Chapter 9

Chapter 9 summarized data derived from previous chapters as conclusion of this research. The chapter specified the divisions of the study area to 16 shores and the adjacent area to those shores that known with riverfronts. The divisions of these shores are related to previous studies and characteristics of the study area in Greater Khartoum. The chapter summarized the proposal development elements for each Nile River Shore and make categorization for the 16 shores as specified below:

- **Summary of Development of the Blue Nile Shores**

The chapter specified the six Blue Nile Shores that facing Khartoum and Khartoum North. The chapter specified the hydrology of the Blue Nile as main driving force for stabilization methods for Nile River Banks due to its high fluctuation discharge flow. The chapter summarized the current situations of these shores and the main development elements that required for developing those shores and their riverfronts in the proposal development plan.

- **Summary of Development of the White Nile Shores**

The chapter tackled the specifications of the four wide White Nile Shores that facing Khartoum and Omdurman. The chapter specified the hydrology of the White Nile and its wide shores due to the stable discharge flow of the river. The chapter summarized the current situations of these shores and their adjacent areas that known as riverfronts. The chapter also summarized the main proposal development issues and elements as specified in the proposal development plan for them.

- **Summary of Development of the Main Nile Shores**

The chapter specified that the Blue and White Nile are merged in Khartoum forming the Main Nile where Greater Khartoum located at the confluences of these rivers. The chapter specified the three Main Nile Shores and they are facing Omdurman and Khartoum North. The chapter summarized the current and the proposal situations for those shores as derived from previous chapters and as specified in the proposal development plan.

- **Summary of Development of the Confluences Shores at Tuti Island**

The chapter specified that composed of; the Left Blue Nile Branch facing Khartoum, the Right Blue Nile Branch facing Khartoum North and the Main Nile facing Omdurman. The confluences composed of three shores with total length of 10.375 km. The chapter specified the current characteristics of these shores and their potentiality for sustainable development. The chapter summarized the main development elements as specified in the proposal development plan.

- **Summary of Development of the Potential Nile River Shores**

The chapter tackled three potential shores in our study area as an example of how the Nile River Shores in Greater Khartoum could be developed in sustainable manner. The chapter tackled the development of one shore on the Blue Nile, one shore on the White Nile and one shore on the Main Nile. The chapter specified the main development issues that required for these three potential shores in the proposal sustainable development plan for the development of the Nile Riverfront in Greater Khartoum.

CHAPTER TEN: RESEARCH LIMITATION

10:0 Introduction

Chapter ten is the last chapter in this study for the research limitation. The chapter will tackle the following issues:-

- Barriers and constrains that restricted the implementation of the development of the Nile riverfront in Greater Khartoum and the chapter will specify the suggestions of guidelines for solving those barriers and how to overcome over them.
- Recommendation policies for implementation process where the chapter will investigate guidelines that required for various visions in national and local policies. The chapter also will specify the short and long implementation programs and how each development elements will be managed and finance within the overall comprehensive planning and the structural plan of Greater Khartoum.
- The chapter will specify the further issues that required more investigations and research particularly this research is the first one that tackles two main areas that related to; stabilization methods for the Nile River Banks and sustainable development of the shores adjacent to those banks in Greater Khartoum.
- The chapter finally will specify how the research carried in one of the unique area in the world although it is located in one of the poorest countries where there is no scientific data and even the available data it is not accessible. The research also will specify the lacks of institutions and technology that required for scientific research. Finally the chapter will specify the unique location of the study area where no similar to it in the world.

10:1 Barriers and Constraints that Restrict the Implementation of the Development Plan

The implementation process of the development plan for SDNRF at Greater Khartoum will be restricted by the following barriers and constraints as specified below:

10:1:1 Lack of Water Management of the Nile River

There is a lacks of water management for the Nile River in the study area that affect the development of the Nile River Shores. Lacks of water management occur from the high discharge and fluctuation flows of the Blue Nile River as specified in the study of the UNESCO Chair in Water Resources (2002,Volume 5). The study specified that the Blue Nile is a main driving force for the development of the Nile River Shores due to the high fluctuation discharge flow between flood and dry season. The discharge of water in flood season is (700 mm^3/ day) where in dry season is (10 mm^3/ day). This river pattern system leads to large seasonal fluctuation of water levels from low level of about 373.06 meters above sea level (m.a.s.l) in dry season to 380.88 m.a.s.l in flood season with variation level of 7.82 m (UNESCO study 2002, V.5, p.12). The White Nile is of stable discharge flow which is (73 Mm^3/day). Therefore these characteristics of the river pattern systems affected each other. The White Nile is affected by the high discharge flow of the Blue Nile in flood season (700 mm^3/day) for the Blue Nile to (73 mm^3/day) for the White Nile and the Blue Nile is affected by a high discharge flow of the White Nile in dry season (73 Mm^3/day) for the White Nile to (10 mm^3/day) for the Blue Nile. Then the two rivers confluences at Almogran forming the Main Nile River as specified before. The Main Nile is affected by the discharge flow and pattern system of the Blue Nile and the White Nile. This fluctuation of flow pattern for Nile River System has significant impact on the development of Nile River Shores and methods of stabilizing Nile River Banks at Greater Khartoum. This lack of water management for the Nile River should be solved so as development for SDNRF at Greater Khartoum can take place properly.

10:1:2 Lacks of Local Materials

The implementation of the development plan for SDNRF at Greater Khartoum required special types of construction materials. These materials such as steels, cement, gravels, sand, bricks, stones, wood and various construction materials that is used for different development elements and methods of stabilizing river banks. The construction materials that required for the implementation of the development elements of the SDNRF at Greater Khartoum should have no negative impact to the general environment in the study area. Therefore special consideration should be taken for construction materials that required for implementing different development elements without affecting the general environment of the study area.

10:1:3 Lacks of Local Skills

Some of the development elements of SDNRF at Greater Khartoum required special type of local skills. These development elements that required special type of local skills such as methods of stabilizing Nile River Banks, infrastructures, recreational elements, parks, greenway system, river traffic system and various development elements along the Nile River Front. The local skills that required for implementing those development elements such as professionalisms, professional engineers, professional managers, well trained technicians, well trained craftsmen and various labours of good experience those required for implementing the different development elements.

10:1:4 Lacks of National and Local Economic Situations

Implementation of the different development elements of SDNRF at Greater Khartoum for the sixteenth Nile River Shores required a large amount of local and hard currents. Sudan is considered one of the potential countries in Africa due to its diversification resources whether on the ground or under the ground, but it is one of the poorest countries in the world due to unsustainable political situation and civil wars particularly in Darfur. Now there is some progress in economic situation as a resultant of Comprehensive Peace Agreement CPA (2005) between North and South Sudan, increase in petroleum production and increase of foreign investors. This situation leads to rapid economic growth particularly our study area is the most potential area in Khartoum that should be considered in National Economic Strategy of Sudan.

10:1:5 Lacks of Laws and Regulations

There is a lack in general laws and regulations that required for controlling and directing the various kinds of development in Sudan. Therefore there are requirements for basic laws and regulations that directing and controlling the development in this important and valuable area in Sudan along the Nile River Front at Greater Khartoum.

10:1:6 Lacks of Public Awareness

There is a lack of public awareness about general sustainable development particularly about SDNRF at Greater Khartoum. The lack of public awareness about sustainability due to the absent of institutions and channels of knowledge in Greater Khartoum that lead to raise public information about sustainable development.

10:1:7 Lacks of National and Local Policies

There is a lack of national and local policies that required for directing and controlling the development for the Nile River Shores at Greater Khartoum. There are no formulation policies that tackle the development of those Nile Shores.

10:2 Suggestions of Solutions for Barriers and Constraints

Suggestion for solutions and overcomes for those barriers and constraints that restricted the implementation of SDNRF at Greater Khartoum will be as specified below:

10:2:1 Construction of Dams and River Echo System

Lacks of water management in the study area as specified in previous section, will be obtained from construction of dams that lead to stable discharge flow of water in the Nile River similar to water management in Egypt that obtained after the construction of Aswan High Dam in 1968 as specified in chapter five. The important dams that lead to stable discharge flow of water in the study area, particularly on the Blue Nile as main driving force that affect development of the Nile River Shores as specified in previous study are:

(i) Construction of new dam at upper stream of the Blue Nile so as to manage water at the back of the dam that includes our study area. Location of this new dam will be

determined according to suitable engineering studies that required for this project. Although there are two dams on the Blue Nile one at Sinnar and the other at Rosaris, but they are too small dams to manage the high discharge flow of water of the Blue Nile particularly within flood season.

(ii) Construction of new dam at upper stream of the White Nile which will lead to more management of the stable discharge flow of the White Nile ($73Mm^3$/day). The new dam location will be according to require engineering studies.

(iii) Construction of the proposed project for Rosaris Dam at Damazine on the Blue Nile to increase its height and capacity as specified in National Strategy, but fortunately not executed yet. This project will lead to more water management and increase the agriculture area in Sudan.

(iv) Construction of proper modern echo system for the Blue Nile, the White Nile and the Main Nile River.

10:2:2 Constructions of Local Industries

There is a lack of local materials that required for constructing development elements and stabilization methods for Nile River Banks. These materials such as steel, cement, gravels, sand, bricks, blocks, stones, tiles, timber, wood, electric fittings, plumbers fittings, paints, construction equipments and different construction materials. Most of these important materials are available in Sudan but not sufficient and of low quality. Therefore, the following suggestions should be considered so as to raise availability and quality of these construction materials that required for implementation of SDNRF elements in the study area:

(i) Construction of local industries to manufacture building materials from local raw materials with special consideration to environment.

(ii) Construction of local industries for manufacturing technical equipments that required for construction and implementations.

(iii) Construction of special local industries to manufacture local materials for the construction of the development elements that familiar to environment such as equipments that can use solar energy, wind and hydraulic energy.

(iv) Encouraging research for innovations, developments and building materials.

10:2:3 Training

Lack of local skills can be solved by the following suggestions:

(i) Establishment of technical schools that specialized in particular type of work that lead to increase the general knowledge in the different crafts such as carpenters, plumbers, electricians, mechanics, builders, farmers etc.

(ii) Construction of vocational training centres to raise skills and knowledge of the workers and labours in different constructional fields.

(iii) To encourage international training for professionalisms in a developed countries.

(iv) To encourage governmental and private local companies to make joint ventures with international companies so as to raise their standardization.

(v) To import international technique and last innovations for implementation of the development elements of SDNRF at Greater Khartoum.

10:2:4 Economic Improvements

The following suggestions should be considered to improve economic situation and financing implementation process of SDNRF elements at Greater Khartoum:

To collect some money by certain taxes from local materials in Greater Khartoum and this collected money will contribute in financing the implementation of the various development elements.

(i) To stop civil wars in Sudan particularly that in Darfur and to use part of its money expenditure in financing the implementation process.

(ii) Invitation of local investors to contribute in financing the different development elements of SDNRF at Greater Khartoum.

(iii) To invite foreign investors to invest in the different development elements.

10:2:5 Stipulations of Laws and Regulations

Lack of laws and regulations for the development of SDNRF at Greater Khartoum will be solved by the following suggestions:

(i) Stipulation of land laws that required for specifying land registrations, land types, land owners, land compensations and land holders.

(ii) Laws for land reclamations and occupation of private and governmental lands for the development of lands along Nile River Shores at Greater Khartoum.

(iii) To establish Environmental Impact Assessment EIA statements and laws for various development elements.

(iv) To establish building regulations that required for controlling, managing and directing implementation process.

(v) Stipulation of building standards regulations according to the international and local standards such as, British Standards BS, Codes of Practice CP, ISO, American Standards and European Standards.

(vi) Determination of local and national authorities for SDNRF at Greater Khartoum in the various levels of planning Regional, National and Local level.

(vii) Creation of new body “Initiative Body” that will be responsible from the implementation of SDNRF at Greater Khartoum.

(viii) Stipulation of Planning Regulations.

10:2:6 Increase of Public Awareness

Lack of public awareness about sustainability and SDNRF at Greater Khartoum can be solved by the following suggestions:

(i) To establish public institutions for sustainable development to raise public awareness about SDNRF at Greater Khartoum.

(ii) To establish Non Governmental Organizations NGOs and Public Unions for the different categories of the society such as labour union, farmer union, employee union, trade union etc.

(iii) To encourage public participation about sustainable development of the Nile River Front by NGOs, Public Unions, Common Seminars and Workshops.

(iv) To encourage the establishment of local libraries and internet centres.

(v) To publish SDNRF Manual that illustrates and specifies the development plan for Sustainable Development of the Nile River Front SDNRF at Greater Khartoum.

10:2:7 National and Local Policies for Development of the Nile Shores

There is a need for establishing national and local policies as guidelines for developing the 16 Nile Shores. These policies should be specified in the national and local strategies that lead to the development of the Nile River Front in Greater Khartoum.

10:3 Recommendations Policies for Implementation Process

The following recommendations should be considered for implementation of the final version of the development plan of SDNRF at Greater Khartoum as specified below:

10:3:1 Vision for SDNRF at Greater Khartoum in National and Local Policies

The implementation of the development plan of SDNRF at Greater Khartoum should be considered in the general strategy of Sudan within long and short run as specified below:

(i) The National Strategy of Sudan should tackle the development of the Nile River Front at Greater Khartoum.

(ii) The Political Strategy should give special consideration and vision for the development of the Nile River Front in our study area.

(iii) The development plan of SDNRF at Greater Khartoum should be considered into various planning levels National, Regional and Local Level with special consideration for the Nile Basin Initiative NBI policies for the Nile River in the ten Nile Countries.

(iv) The structural plan of Greater Khartoum should gives special consideration for developing the Nile River Shores.

10:3:2 Implementation Programmes for SDNRF at Greater Khartoum

Implementation of development elements for SDNRF at Grater Khartoum at the sixteenth Nile River Shores will be as specified below:

(i) The Implementation of the SDNRF elements will be according to the programme in the Comprehensive and the Structural Plan of Greater Khartoum.
(ii) The implementation of the development elements of SDNRF at Greater Khartoum will be due to their potentiality, important, demand, finance, development and strategy as specified in Long and Short Term Programme.
(iii) The implementation of the SDNRF at Greater Khartoum will be according to the Long Term Programme that specified how the development will take place on the sixteenth Nile River Shore.
(iv) The implementation of the plan will be according to the Short Term Programme that specified how the development will take place on each Nile River Shore.
(v) The implementation of the development elements will be according to the Local Programme that specified how the units in each development element will take place on each Nile River Shore.

10:3:3 Laws and Regulations for SDNRF at Greater Khartoum

The essential laws and regulations for SDNRF at Greater Khartoum will be as specified below:

(i) Land Laws that required for organizing and specifying those related to lands such as types, uses, reclamation, regulations, owners, compensation, development, etc.
(ii) Building Regulations that required for controlling and directing the development elements within implementation process such as general regulations, regulations for different building types (residential, commercial, industrial, recreational, etc), building

height, building ratio, floor area ratio, building services, boundaries regulations, building levels, disposal and drainage system, etc.

(iii) Building Standards that specify the required standardization for each development element.

(iv) Planning Regulations for different planning levels National, Regional and Local level.

(v) EIA statements for different development elements.

(vi) NBI Regulations should be considered for the general regulations and laws of the ten Nile Countries.

(vii) SDNRF Manual that specify the whole development in the study area.

(viii) Building Authorities Regulations BAR which specify different responsibilities for each development authority at the different planning levels.

10:3:4 Managements for SDNRF at Greater Khartoum

Management for the implementation of the different SDNRF urban elements at Greater Khartoum will be as specified below:

(i) To establish initiative body that responsible from implementation of the development elements along Nile River Shores or SDNRF at Greater Khartoum according to specifications, drawing, laws, regulations, standards, strategies, policies, environmental requirements, economic requirements and social requirements.

(ii) Coordination between different authorities that responsible from the implementation of SDNRF at Greater Khartoum such as Ministry of Irrigation, Ministry of Finance Authority, National Authority, Greater Khartoum Authority, Environmental Authorities, Tourists Authorities, Local Councils Authorities etc.

(iii) Monitoring of development elements within the implementation process.

(iv) Continuation of following up of the different development elements.

(v) Maintenance of different development elements.

10:3:5 Finances for SDNRF at Greater Khartoum

Finance for implementing different development elements of SDNRF at Greater Khartoum will be as specified below:

(i) Contribution of National Resources such as petroleum income, mining income (gold, steels, chromium, zincs etc), agriculture income and live stock income.

(ii) Contribution of different regions (26 Wilayas) from their own resources.

(iii) Contribution of taxes from specific products.

(iv) Contribution of local councils in Greater Khartoum from their own local resources.

(v) Contribution of international financers such as World Banks, European Union, African Development Bank, Islamic Development Bank, Arab Banks etc.

(vi) Local Developers whom can contribute in financing the implementation of the different development elements.

(vii) International Developers whom can contribute by making join ventures with local developers or land owners in financing any of the development elements according to the development requirements.

10:4 Areas for Further Research

This research tackles a wide large two areas for sustainable development stabilization methods for Nile River Banks and urban development elements along Nile River Shores at Greater Khartoum. These two large areas each of which recommend further studies as specified below:

10:4:1 Echo System for the Nile River

Echo System can be established on the Nile River which will lead to eliminate flood risqué that occurs annually within flood period due to high discharge flows of water from the Blue Nile which about 700 Million M^3/ day that causes great loss to population and their properties. This Echo System for the Nile River required proper studies and simulations models for the Nile River which can be obtained by further studies on this essential area so as to construct proper Echo System on the Nile River.

10:4:2 Water Management of the Nile River

Water Management of the Nile River can be gained by construction of dams that lead to proper water management, similar to Aswan High Dam in Egypt which leads to proper water management downstream along the Nile River in Egypt. Water Management of the Nile River at Greater Khartoum required further studies such as simulation models for water management of the Nile River, construction of dams after determining their proper locations, the environmental and socioeconomic impacts of these dams etc.

10:4:3 Land Use Planning

Land use planning for Nile River Shores is a wide area that required further studies which can be obtained from development of land use planning model using the latest GIS techniques. Further land use planning can tackle the following areas:

(i) Information that required in delivering and testing the GIS planning tool.

(ii) Highlight innovative tools and techniques for the Land Use system to be used.

(iii) Description of the proposed system to be used including the technology on which it will be based, the processes or procedures of planning and the models that will be used.

(iv) Propose potential future development options.

10:4:4 Sustainable Environmental Studies

Further sustainable environmental studies that required for the Nile River Shores can tackle the following areas:

(i) Development of sustainable environmental indicators for the Nile River Shores.

(ii) Development of a set of guidelines for environmental planning techniques.

(iii) Determination of suitable environmental issues and environmental elements on each Nile River Shores.

(iv) Further studies for socioeconomic situations so as to establish proper socioeconomic planning models for the Nile River Shores.

(v) Further studies on Environmental Impact Assessment EIA for the development elements on the Nile River Shores.

10:4:5 Laws and Regulations

Further studies for laws and regulations that required for controlling and directing the development of the Nile River Shores can tackle the following areas:

(i) Further studies in land laws.

(ii) Further studies in planning regulations for the development of the Nile River Shores.

(iii) Further studies in building regulations.

(iv) Further studies in building standards that controlling the development along the Nile River Front.

(v) Stipulation of clear and specific investment laws for local and foreign developers whom want to develop the Nile River Shores.

10:5 Examples of Carrying Out the Research

The research is carried out in one of the most valuable area that located in one of the poorest country in world. This due to the unique location and characteristics of the study area as specified in previous chapters since it located on the confluences on the longest river in the world. This unique study area there are many difficulties and constrains that restricted scientific integrated approach for appropriate scientific framework for developing Nile Riverfront in Greater Khartoum as specified below:-

10:5:1 Lack of Data

Sudan is classified as one of the poorest country in the world in; economic, democracy, transparency, security and technology due to the international and regional indicators. This situation related to the civil wars in South and West of Sudan that resulted from the unstable politics and ruling of Sudan since its independency from Great Britain and Egypt in January 1956. Sudan was ranked in the study taken by the United Nation in 2005 table 11 for 146 countries due to environmental sustainability index in which data play significance role, Sudan was ranked as 140 as one of the last six countries in the world. Also Sudan was ranked in the study carried by Foreign Policy for 180 countries that measuring degree of perception of corruption according to the corruption perception index No 176 as one of the bad five countries

in the world. This situation let the Sudan to be one of poor, corrupted and unstable country particularly for the sort of data required for sustainable development.

Therefore there is a lack in related data to this research that lead the author to use integrated approach based on exploration methodology. Most of the data used in this research is collected by the author in stages as specified below:-

- **Stage one**

  Local documentary data collected from different sources such as; UNESCO Chair in water resources in Sudan, Survey Department, University of Khartoum, Ministry of Planning, Central Stationary Records etc.

- **Stage Two**

  Primary data collected by the author from the survey for the Nile River Shores and the study area.

- **Stage Three**

  International data collected by the author and observation from his visit to other countries such as; Britain, Egypt, China, France, Germany, Greece, Netherland, Dubai etc.

The author was facing many difficulties in the data collection particularly the local data where there are no specific data that can be useful for this study in specific places. Therefore the researchers always search in different issues so as to find the required information.

Table 10- 1 for the study by UN for the Environmental Sustainability Index

Table 11: 2005 Environmental Sustainability Index – Scores and Rankings (alphabetical order)

ESI Rank	Country Name	ESI Score	OECD Rank	Non-OECD Rank	ESI Rank	Country Name	ESI Score	OECD Rank	Non-OECD Rank	ESI Rank	Country Name	ESI Score	OECD Rank	Non-OECD Rank
24	Albania	58.8		14	67	Greece	50.1	21		2	Norway	73.4	2	
96	Algeria	46.0		70	116	Guatemala	44.0		88	83	Oman	47.9		60
123	Angola	42.9		94	81	Guinea	48.1		58	35	P. N. Guinea	55.2		22
9	Argentina	62.7		3	77	Guinea-Bissau	48.6		54	131	Pakistan	39.9		102
44	Armenia	53.2		28	8	Guyana	62.9		2	28	Panama	57.7		17
13	Australia	61.0	8		141	Haiti	34.8		112	17	Paraguay	59.7		8
10	Austria	62.7	7		87	Honduras	47.4		64	16	Peru	60.4		7
99	Azerbaijan	45.4		73	54	Hungary	52.0	19		125	Philippines	42.3		97
114	Bangladesh	44.1		86	5	Iceland	70.8	4		102	Poland	45.0	27	
47	Belarus	52.8		30	101	India	45.2		75	37	Portugal	54.2	15	
112	Belgium	44.4	28		75	Indonesia	48.8		53	94	Romania	46.2		69
86	Benin	47.5		63	132	Iran	39.8		103	33	Russia	56.1		20
43	Bhutan	53.5		27	143	Iraq	33.6		114	106	Rwanda	44.8		79
20	Bolivia	59.5		11	21	Ireland	59.2	10		136	Saudi Arabia	37.8		107
61	Bosnia & Herze.	51.0		42	62	Israel	50.9		43	59	Senegal	51.1		40
34	Botswana	55.9		21	69	Italy	50.1	22		89	Serbia & Mont.	47.3		66
11	Brazil	62.2		4	109	Jamaica	44.7		82	120	Sierra Leone	43.4		92
70	Bulgaria	50.0		48	30	Japan	57.3	12		48	Slovakia	52.8	18	
97	Burkina Faso	45.7		71	84	Jordan	47.8		61	29	Slovenia	57.5		18
130	Burundi	40.0		101	78	Kazakhstan	48.6		55	93	South Africa	46.2		68
68	Cambodia	50.1		47	100	Kenya	45.3		74	122	South Korea	43.0	29	
50	Cameroon	52.5		32	138	Kuwait	36.6		109	76	Spain	48.8	23	
6	Canada	64.4	5		80	Kyrgyzstan	48.4		57	79	Sri Lanka	48.5		56
25	Central Afr. Rep.	58.7		15	52	Laos	52.4		34	140	Sudan	35.9		111
104	Chad	45.0		77	15	Latvia	60.4		6	4	Sweden	71.7	3	
42	Chile	53.6		26	129	Lebanon	40.5		100	7	Switzerland	63.7	6	
133	China	38.6		104	121	Liberia	43.4		93	117	Syria	43.8		89
23	Colombia	58.9		13	126	Libya	42.3		96	145	Taiwan	32.7		116
39	Congo	53.8		24	22	Lithuania	58.9		12	134	Tajikistan	38.6		105
18	Costa Rica	59.6		9	90	Macedonia	47.2		67	63	Tanzania	50.3		44
88	Côte d'Ivoire	47.3		65	64	Madagascar	50.2		45	73	Thailand	49.7		51
19	Croatia	59.5		10	74	Malawi	49.3		52	111	Togo	44.5		84
53	Cuba	52.3		35	38	Malaysia	54.0		23	139	Trinidad & Tob.	36.3		110
92	Czech Rep.	46.6	25		41	Mali	53.7		25	55	Tunisia	51.8		36
113	Dem. Rep. Congo	44.1		85	124	Mauritania	42.6		95	91	Turkey	46.6	24	
26	Denmark	58.2	11		95	Mexico	46.2	26		144	Turkmenistan	33.1		115
119	Dominican Rep.	43.7		91	58	Moldova	51.2		39	57	Uganda	51.3		38
51	Ecuador	52.4		33	71	Mongolia	50.0		49	108	Ukraine	44.7		81
115	Egypt	44.0		87	105	Morocco	44.8		78	110	United Arab Em.	44.6		83
118	El Salvador	43.8		90	107	Mozambique	44.8		80	65	United Kingdom	50.2	20	
27	Estonia	58.2		16	46	Myanmar	52.8		29	45	United States	52.9	17	
135	Ethiopia	37.9		106	32	Namibia	56.7		19	3	Uruguay	71.8		1
1	Finland	75.1	1		85	Nepal	47.7		62	142	Uzbekistan	34.4		113
36	France	55.2	14		40	Netherlands	53.7	16		82	Venezuela	48.1		59
12	Gabon	61.7		5	14	New Zealand	60.9	9		127	Viet Nam	42.3		98
72	Gambia	50.0		50	66	Nicaragua	50.2		46	137	Yemen	37.3		108
56	Georgia	51.5		37	103	Niger	45.0		76	60	Zambia	51.1		41
31	Germany	56.9	13		98	Nigeria	45.4		72	128	Zimbabwe	41.2		99
49	Ghana	52.8		31	146	North Korea	29.2		117					

Note: The 2005 ESI scores are not directly comparable to the 2002 ESI Scores. See Appendix A for details on the methodology.

Table 10-1 illustrates the low scores of the environmental indicators for the Sudan.

10:5:2 Difficulty of Accessibility to Data

Accessibility to data in Sudan is very difficult due to the general military opinion where most the leaders and decision makers were appointed by the military ruler irrespective to their qualifications that lead to damage the public services and poor perception to researchers. The available data is not directly related to the required issues that make the researcher to do a lot of investigations and classifications to sort out applicable and related data to those specific issues. Therefore in general the researchers in Sudan find many difficulties in finding reasonable way of accessibility to data and actually it is depend on the special relationship between the researchers and the officers who responsible from the authority, institution or the place in which the data is available. This situation leads to poor performance and standardization of researches particularly for those depend on local available data. For this reason the author in this research used integrated approach for exploring survey and observation data as primary data with documentary data to be analyzed scientifically for the comprehensive framework for developing Nile Riverfront in Greater Khartoum. The data collected in this research will be useful for future researchers and will act as a base for future studies.

10:5:3 Lacks of Institutions

Since Sudan is classified as one of the most five poor countries in the world there is an absent of institutions and modern channels of knowledge that lead to lack public awareness about sustainable development and public participation. Some of local authorities now try to establish digital library and electronic data that offers free digital access to knowledge on the current version SOA 3.0. The electronic data is just now covering historical issues for the different regions of the Sudan. This electronic data in the public digital library is considered now as a first trial for electronic data as new idea that required a lot of other works so as to be useful for scientific research and approach methods. Till now there is no scientific and professional institution in Sudan that can offer scientific knowledge for any scientific research. This situation let the researchers to collect information from foreign professional institutions that tackled some of the Sudan issues particularly after the Comprehensive Peace Agreement CPA which signed between the Government of Sudan GOS and the Sudan People’s Liberation Movement/ Army SPLM/A.

10:5:4 Interrelations of Local Authorities

Historically Sudan is of continuous alteration as modern country since it became one union country in 1821 AD except Darfur, where it was independent and ruled by local sultanate. The alterations in local authorities occurred due to the instability of the political situations. Since the independence of the Sudan in 1956, it has been ruled by a series of unstable parliamentary governments and military regimes. The absence of the modern technical system and methodology of local authorities leads to continuous alterations and interrelation of them within each ruling period. The instability of the ruling systems and their impact to local authorities and the interrelations of them are summarized in the below Table 10-2.

Table 10-2 Instability of the ruling system in the Sudan

Time Period	Historical Period	Notes
1820 AD to 1885 AD	Turkish Egyptian Period	1- Divisions of the Sudan to 6 provinces then 7 after adding Taka on 1834. 2- The independence of Darfur Sultanates. 3- The interrelation of the local provinces and authorities.
1885 - 1898	Madhya Period	1- Divisions of the Sudan to new Islamic States and expanded till Ethiopia and South Egypt. 2- The interrelations of the revolution regimes and ruling methods. 3- The total damage of the Turkish system and the authorities.
1898- 1956	British Egyptian or Condominium Period	1- Divisions of the Sudan to 9 provinces where Darfur became part of the Sudan in 1916 and establishment of the current Sudan. 2- The establishments of modern and scientific authorities, but the 6 provinces at the North were different from the 3 ones at the South. 3- Formulation of modern policies and administrations.
1956- 1958	First Parliamentary Democratic Government Period	1- The same condominium system and divisions. 2- The interrelations of the local authorities resulted from the disqualifications of some of the local managers after the independence of the Sudan.

		3- The Sudanization of the public services.
1958- 1964	First Military Regime Period	1- The damage of the democratic authorities and creation of new ones. 2- The alterations of rules and local authorities. 3- Formulation of autocratic policies.
1964- 1969	Second Parliamentary Democratic Government Period	1- Creation of new democratic regulations and authorities. 2- Instability of the governments between the various democratic parties. 3- Democratization of the autocratic policies.
1969- 1985	Second Military Regime Period	1- Formulation of new autocratic policies. 2- New divisions of the Sudan to Seven regions. 3- Lacks of legislations and scientific development programmes.
1985- 1989	Third Parliamentary Democratic Government Period	1- Formulation of new democratic policies. 2- Instability of the government between Umma Party and the other parties. 3- Interrelationship between various local authorities. 4- Lacks of public awareness and how to sustain democracy.
1989 – till now	Third Military Regime Period	1- Damage of democracy and formulation of new Islamic policies. 2- Divisions of the Sudan to 26 Welayas and they divided to 121 provinces. 3- The autocratic Islamic regimes that lead to withdrawn most the professionalisms by those belong to National Islamic Front irrespective to their qualifications. 4- Deterioration of local authorities.

Table 10-2 illustrated the instability of the governments and each government make significant alterations and formulated new policies and legislations that led to the instability and interrelationship of local authorities.

10:5:5 Lacks of Technology

Sudan is facing problem of knowledge due to lack of technologies that required for various local knowledge and information gathering. The lack of technology is very noticeable and clear in the old and out of date technologies that used now in the different sorts of life in Sudan such as those used in; media, development, communications, industries, constructions, medicine, learning and everything that required in modern life. This situation let the Sudan to be far away from innovation and modern technology that used in developed and even some of developing countries due to the deterioration in the different means of life. Therefore researchers in general are finding many problems and constrains in their research due to lacks of technology in Sudan.

10:5:6 Lacks of Specialist and Professionalism

The political situation in Sudan after the National Islamic Front changed the elected democratic government by their military force in June 1989 every things is altered due to their issues. The new leaders terminated and withdrawn most of the professional academics and specialists from their jobs and appointed their people irrespective to their qualifications. This situation let them to leave their own country and they emigrated to many countries in the world and contributing in the development for those countries particularly in Arab Petroleum Countries and lead to the deterioration and suffering of the internal public sectors in the Sudan. Now Sudan is considered the first country in the world in immigration where the UN reported that from each 8 emigrants there is one Sudanese or Sudanese represent 12.5% from the total emigrants in the world (UN Emigration Report in 15 June 2010). In general Sudan is facing a huge diversity of territories that restricted its sustainable development that required long and short strategic programmes. These programmes required comprehensive understanding carried by all Sudanese people particularly those of high academic knowledge and gained experience irrespective to their political opinion.

10:5:7 Lacks of Similarity of Other Rivers in the World

The unique location of the study area since it located on the confluences of the; Blue and White Nile and emerged together to make the Main Nile which considered as the longest river in the world. The characteristics and hydrology of the; Blue, White and Main Nile are not similar to any other river in the world. Also the six frontages of the study area there is no similar to it in the world. Therefore this research is precedents study to this unique area and will act as a base for future studies and will be similar case to any unique location in the world. For the purpose of this unique study the research tackled some similar areas to understand how their riverfronts are stabilized and developed although they are different in their characteristics and hydrology.

10:6 Summary of Chapter Ten

The chapter specified barriers and constraints restricted the implementation of the Sustainable Development of the Nile River Front SDNRF at Greater Khartoum and suggested solutions for those barriers and constraints. The chapter specified lacks of water management of the Nile River as main barrier that restricted the development of the riverfront and suggested solutions for it, by construction of dams and river echo system that lead to proper water management system and elimination of flood. The chapter specified lacks of local materials barriers and suggested solutions for them by construction of local industries to manufacture and produce local materials that required for implementation process. The chapter specified lacks of local skills and suggested solutions for them by training programmes to raise local skills and standardization. The chapter specified lacks of national and local economic situations which needed to support the finance of the implementation development elements costs and suggested solutions for them by economic improvements through extra taxes, invitation for local and foreign investors, to stop civil wars particularly in Darfur etc. The chapter specified lacks of laws and regulations and suggested solutions for them by stipulation of laws and regulations that required for controlling and directing the development of the Nile River Front at Greater Khartoum such as land laws, building regulations, planning regulations, building standards etc. Also the chapter specified lacks of public awareness about sustainable development and suggested solutions for them by increasing public awareness through proper establishment for public institutions, Non

Governmental Organizations NGOs, common workshops, communications centres and local libraries.

The chapter specified recommendations for implementation process of the SDNRF at Greater Khartoum which should be considered in national and local policies due to the implementation programmes. The chapter specified the most essential laws and regulations that required for controlling and directing the implementation process such as land laws, building regulations, building standards, planning regulations, EIA statements and SDNRF Manual. The chapter specified the implementation managements and finance for the different development elements. The chapter specified final summary of the research for the development of the sixteenth Nile River Shores along the Blue Nile, the Confluences at Tuti Island, the White Nile and the Main Nile River. These Shores are facing Khartoum, Omdurman, Khartoum North and Tuti Island.

The chapter specified the areas that required further research such as echo system for the Nile River particularly for the Blue Nile due to its high fluctuation flows, water management, land use planning, environmental studies, essential laws and regulations. The chapter also specified how the research is carried in one of the most unique area in the world although it is located in the poorest country. The country is poor in various means of modern life such as; technology, institutions, professionalisms, rare of scientific data and accessibility to it.

Finally this and previous chapters of this study should be incorporated with the appendices that coming in the next sections that will tackle the following issues:

- Appendix 1 which will tackle the questionnaire for stakeholders and the reply of the intellectual stakeholders.
- Appendix 2 that will present cross sections for the Nile River in the study area.
- Appendix 3 which will tackle guidelines for stipulating land laws that required for land specifications and reclamations.
- Appendix 4 that will tackle building regulations that required for developing different land uses.
- Appendix 5 which will be about building standards that are standardizing different development elements due to national, regional and local standards.
- Appendix 6 which will specify the environmental impact assessment for better environmental improvements.

- Appendix 7 which will specify the SDNRF Manual. This manual composed of the different guidelines for development of the Nile River Front in Greater Khartoum that contribute in raising the public awareness in the study area.

APPENDIX 1: QUESTIONNAIRE FOR STAKEHOLDERS

Questionnaire

Sustainable Development of the Nile River Front at Greater Khartoum

Preamble:

Khartoum is the capital of Sudan, located in the confluence of the Blue and the White Nile and on the shores of the Main Nile. Khartoum is one of the few world Cities with these rich water front (six fronts) and at the junctions of the three rivers. In the last decade, Khartoum witnessed a rapid economic development and huge investments. There is a danger that this rapid growth without a sustainable development vision and planning. The objective of this research is to identify and quantify the critical factors for the success of developing the waterfront of the Greater Khartoum area.

Since, stakeholder consultation is essential to provide support and comments to improve and enhance this research, this questionnaire was prepared.

Please provide your comments on the following guiding questions, as well as your general comments:

- ***Do you agree with the suggestions provided in this development plan? (If yes, specify your positive comments and if No, elaborate on your constructive critiques)***

……
……
……
……..

- **What *change and improvements would you suggest for the River Fronts?***

……
……
……
……
……
…….

- ***<u>Can you identify any barriers to the plan implementation?</u>***

……

……

……

……..

……..

- ***<u>The Author included the Egyptian experience, what lessons could be drawn?</u>***

……

……

……

……

……

…….

- ***<u>Your general comments?</u>***

……

……

……

……

……

……....

Name: ……

Title: ……..

Affiliation/ Institution: ……..

Questionnaire

Sustainable Development of the Nile River Front at Greater Khartoum

Preamble:

Khartoum is the capital of Sudan. It is located in the confluence of the Blue and the White Niles and on the shores of the Main Nile. Khartoum is one of the few Cities in the world with these rich water fronts (six fronts) and at the junctions of three rivers. In the last decade, Khartoum witnessed a rapid economic development and huge investments. Therefore a sustainable planning and development vision for its riverfronts is needed. The objective of this study is to identify and quantify the critical factors for developing the waterfronts of the Greater Khartoum area and hence set out guidelines for the master plan.

Since, stakeholders' consultation is essential a questionnaire is prepared to obtain their comments to improve and enhance this study.

Please provide your comments on the following guiding questions, as well as your general comments:

- ***Do you agree with the suggestions provided in this development plan? (If yes, specify your positive comments and if No, elaborate on your constructive critiques)***

  Yes, particularly this study is establishing guidelines and sustainable indicators for the main issues that required for developing Nile Riverfronts in Greater Khartoum based on scientific exploration approach. The study tackled the main factor required for developing Nile Riverfront in scientific pragmatic approach, i.e. stabilization of Nile banks, so development of Nile shores adjacent to those banks can take place safely. The present study is a useful example for urban rivers in Africa in particular and the world in general. Therefore this research will contribute and add to knowledge as it acts as a baseline for any sustainable development of urban riverfront.

- ***What change and improvements would you suggest for the River Fronts?***

I agree with the general concept to act as a framework for stabilizing and developing Nile Riverfront in Greater Khartoum, but further study for the banks soils should be taken. This study is mainly related to technical engineering works that can be taken within the implementation process or by further research as suggested by the author. These also can be done by; Ministry of Irrigation in Sudan or by the UNESCO Chair in Water Resources in Sudan.

- ***Can you identify any barriers to the plan implementation?***

The main constraint is the finance, which could be solved by calling international and foreign investors. The others constraints are related to; the interrelation of local and national responsibilities, owners of some private lands, however this study put forward some guidelines that contribute in solving these problems by stipulating laws and regulations that required in the implementation phase.

- ***The Author included the Egyptian experience, what lessons could be drawn?***

The selection of Cairo city by the author is convenient and very useful due to the similarities and links between Cairo and Khartoum in different aspects. The author used the Egyptian experience in Cairo to stabilize and develop Nile Riverfront in Khartoum taking into consideration the differences in the water management between the two cities. This is attributed to the presence of Aswan High Dam which controls the water flow in the Nile River.

- ***Your general comments?***

The study will be supported by UNESCO Chair in Water Resources in Sudan (UNESCO-CWR) and will advocate and promote the project among the different national and local authorities in Sudan. This study falls within the line of research of UNESCO-CWR. The current applied activities in the Nile Riverfront are ***ad-hoc;*** therefore, this study will

contribute in establishing ***scientific framework*** for stabilizing and developing Nile Riverfront in Khartoum.

Name: **Professor Dr. Abdalla Abdelsalam Ahmed**

Title: **Director General of UNESCO Chairs in Water Resources - Sudan**

Affiliation/ Institution: **UNESCO Chairs in Water Resources - Sudan,** (*aaahmed55@yahoo.com*), Tel (+249912206586).

Prof. Dr. Abdalla Abdelsalam Ahmed
Director General, UNESCO Chair in Water Resources (UNESCO-CWR)
P.O.Box:1244 Khartoum11111,Sudan
Tel:+249-183-779599/786770/776884
Fax:+249-183-797758
E.Mails: aaahmed55@yahoo.co.uk
aaahmed55@ucwr-sd.org
aaahmed55@gawab.com
aaahmed55@hotmail.com
website: http//:www.ucwr-sd.org

Questionnaire

Sustainable Development of the Nile River
Front at Greater Khartoum

Preamble:

Khartoum is the capital of Sudan, located in the confluence of the Blue and the White Nile and on the shores of the Main Nile. Khartoum is one of the few world Cities with these rich water front (six fronts) and at the junctions of three rivers. In the last decade, Khartoum witnessed a rapid economic development and huge investments. There is a danger that this rapid growth without a sustainable development vision and planning. The objective of this research is to identify and quantify the critical factors for the success of developing the waterfront of the Greater Khartoum area.

Since, stakeholder consultation is essential to provide support and comments to improve and enhance this research, this questionnaire was prepared.

Please provide your comments on the following guiding questions, as well as your general comments:

- ***Do you agree with the suggestions provided in this development? (If yes, specify your positive comments and if No, elaborate on your constructive critiques)***

Yes: It is an integrated approach, taking into consideration environmental, social and technical issues. I have noticed many initiatives to develop the Nile Fronts and many discussions on the economic of these fronts, but all are project site specific ideas and activities. In addition, the sustainable development is for the first time to be addressed in this research.

- ***What change and improvements would you suggest for the Rivers Fronts?***

I will follow the proposal outline, corridors, recreation, navigation, and other tourist functions, accessibility and link with town planning to avoid congestion and environmental hazards and pollution of the river. However, these could be taken during the planning for implementation; the research could provide directions on further future work.

- ***Can you identify and barriers to the plan implementation?***

The only constrain is the finance, however, the private sector (local and foreign) has capability and capacity to be engaged in such projects. The implementation could be phased and put in lots for different types of implementers (public, private (local, regional and international), further detailed studies are needed, including promotion.

- ***The Author included the Egyptian experience, what lessons could be drawn?***

Egyptian experience was good, relevant and easy to learn from. Egypt experience on the Nile fronts development remain to be compared with the Nile in Sudan, since most of Sudanese senior professionals and entrepreneurs visit Egypt; though Great Khartoum gifted with 6 fronts, in addition to Tuti Island facing the three main town (Khartoum, Khartoum North and Umderman).

- ***Your general comments?***

I support the proposal adopted by the Author of the research and I hope the Authorities will take further and seriously for implementation. I am ready to provide the needed support to the local Authorities and the research outcome to be realized. I do support integrated approach in development and currently working on that.

Name: Ahmed Khalid Eldaw Title: Civil Engineer (BSC, Dip, MSc, PhD)
Affiliation/ Institution: Executive Director, Eastern Nile Technical Regional Office (akhalid@nilebasin.org) Tel (00251-911-252529; 00249 9122 58047

Questionnaire

Sustainable Development of the Nile River Front at Greater Khartoum

Preamble:

Khartoum is the capital of Sudan, located in the confluence of the Blue and the White Nile and on the shores of the Main Nile. Khartoum is one of the few world Cities with these rich water front (six fronts) and at the junctions of the three rivers. In the last decade, Khartoum witnessed a rapid economic development and huge investments. There is a danger that this rapid growth without a sustainable development vision and planning. The objective of this research is to identify and quantify the critical factors for the success of developing the waterfront of the Greater Khartoum area.

Since, stakeholder consultation is essential to provide support and comments to improve and enhance this research, this questionnaire was prepared.

Please provide your comments on the following guiding questions, as well as your general comments:

- ***Do you agree with the suggestions provided in this development plan? (If yes, specify your positive comments and if No, elaborate on your constructive critiques)***

  The suggested plan was based on scientific and logical approach therefore I do agree with it. However, changes will be needed as a must during implementation mainly because of the dynamics in utilization of the shores and interference of local authorities mainly in selling the land for foreign investors who are looking for commercial benefits rather than satisfying international standards.

- ***What change and improvements would you suggest for the River Fronts?***

  As for the river front protection and because of the existence of intensive areas of flood plains, other technical measures like control of seepage below the protection structures and

existence of weak soils may influence the selection of the type of protection. Aesthetic and land use factors are also important when we select options like earth embankments which occupy large areas and are not beautiful.

- ***Can you identify any barriers to the plan implementation?***

The main barrier, other than the absence of finance, for the implementation of the plan is the interference of non-technical authorities in changing the existing situation and the absence of integrated plans that will satisfy the objectives of this nice development plan. The river banks are currently suffering from intensive bank erosion north of Shambat Bridge and some strategic shore areas have been sold to investors in the absence of overall strategic plan and protective legislations.

- ***The Author included the Egyptian experience, what lessons could be drawn?***

The review given for the Cairo experience is fantastic and comprehensive. We should learn from the mistakes of our elder brothers north of the Wadi. The basic guideline that the river front should be accessible to all citizens should be strictly implemented at this stage. The author did a good job and the lessons drawn are useful. However, the basic differences between Khartoum and Cairo and the Nile at Khartoum and Cairo (e.g. hydrological, geotechnical and availability of local construction materials etc..) need to be highlighted.

- ***Your general comments****?*

The study is a contribution towards the integrated development of the river fronts and shores of Greater Khartoum. It took into consideration environmental, economical and social issues. I am a bit worried that in the absence of understanding and awareness for the basis upon which such a study has been carried out, it will be difficult to convince those who are concerned to implement it. Therefore the study needs a sponsor who will advocate for it. The time factor is critical since lots of changes are going on along the study fronts.

Name: Dr Ahmed Mohamed Elsharief
Title: Associate professor, Geotechnical Specialist (Fellow, FSES and Consultant, SEC.

Affiliation/ Institution: Director of Building and Road Research Institute, University of Khartoum, Sudan (aelsharief@yahoo.com) Tel (00249912144181)

Questionnaire

Sustainable Development of the Nile River Front at Greater Khartoum

Preamble:

Khartoum is the capital of Sudan, located in the confluence of the Blue and the White Nile and on the shores of the Main Nile. Khartoum is one of the few world Cities with these rich water front (six fronts) and at the junctions of the three rivers. In the last decade, Khartoum witnessed a rapid economic development and huge investments. There is a danger that this rapid growth without a sustainable development vision and planning. The objective of this research is to identify and quantify the critical factors for the success of developing the waterfront of the Greater Khartoum area.

Since, stakeholder consultation is essential to provide support and comments to improve and enhance this research, this questionnaire was prepared.

Please provide your comments on the following guiding questions, as well as your general comments:

- ***Do you agree with the suggestions provided in this development plan? (If yes, specify your positive comments and if No, elaborate on your constructive critiques)***

Yes. It seems that subject addressed a very important topic to Khartoum State specifically and to Sudan in general. Further it comes at the time of growing awareness by public, land owners and, both local foreign investment companies to the vast and untapped investment opportunities along the shore of the three Niles within the Khartoum State.

- ***What change and improvements would you suggest for the River Fronts?***

In line with the proposed idea of fixing or stabilizing the river banks, I think it has to be coupled with stabilization of the water level in the whole reach to optimize the benefits. This stabilization has to be done by implementing the downstream Sabalowga dam project to control the water levels throughout the year. Endless of positive environmental impacts that can be generated. To mention some; i) It will boost tourism industry, ii) makes the river navigable and the river traffic accessible by all parts of the three cities, iii) induces positive climate change to the Khartoum State, iv) reduce pumping cost to irrigation and water supply plants…. Etc.

- ***Can you identify any barriers to the plan implementation?***

The project is huge and costly. It needs phasing and further detailed social, economical, geotechnical and hydraulic studies. However, they should fall within a master plan that adopts an integrated approach

- ***The Author included the Egyptian experience, what lessons could be drawn?***

It is very relevant. However it has been evolved through history in stages that took tens of years. For the Sudan and due to current advance in technology a better project could be implemented in a relatively shorter period if lessons were perfectly drawn from Egyptian experience. It worth mentioning that, Egyptians were successful because they controlled the water level in Cairo by the construction of the delta barrage on the downstream.

- ***Your general comments?***

Being very close and actually participated in committees of the current ongoing development projects that will be implemented along the river fronts there is a high need for strong coordination between the different projects. This has to be done via a sustainable integrated approach. The Author together with relevant institutes such as UCWR and Ministry of Irrigation needs to launch a promotion program to put the outcome of the research. Further, luckily last week Structural Mater Plan of the Khartoum State was formulated and signed Last week by the council of Ministers. The research fall within the interest of the Ministry of

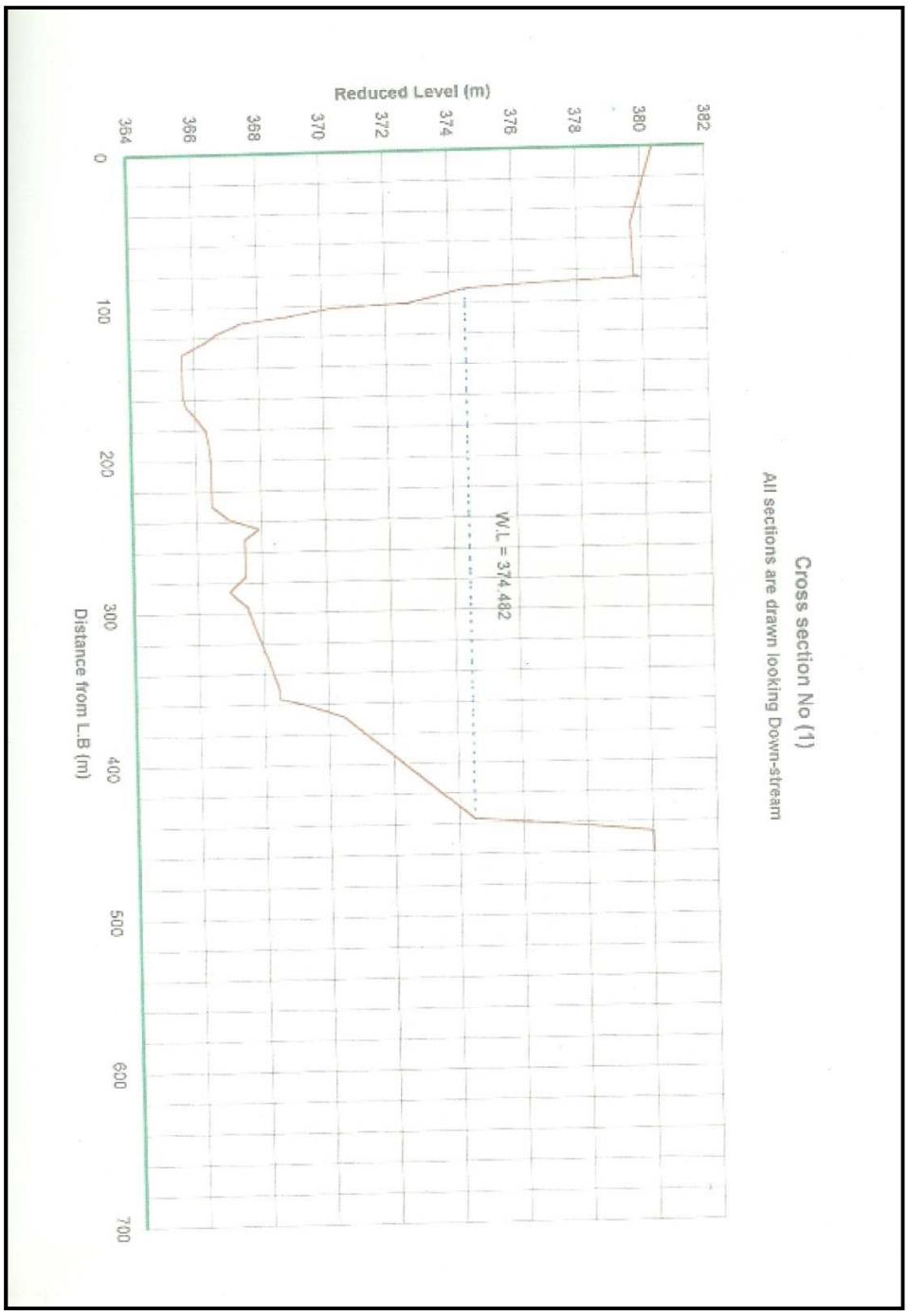
Planning of the Khartoum State and therefore the environment and chance for implementation of the outcomes of the research is promising.

Name:. **Ahmed Musa Siyam**
Title: **Civil Engineer (BSc, Msc[1], Dip. MSc[2], PhD)**
Affiliation/ Institution: **UNESCO Chair in Water Resources**……..

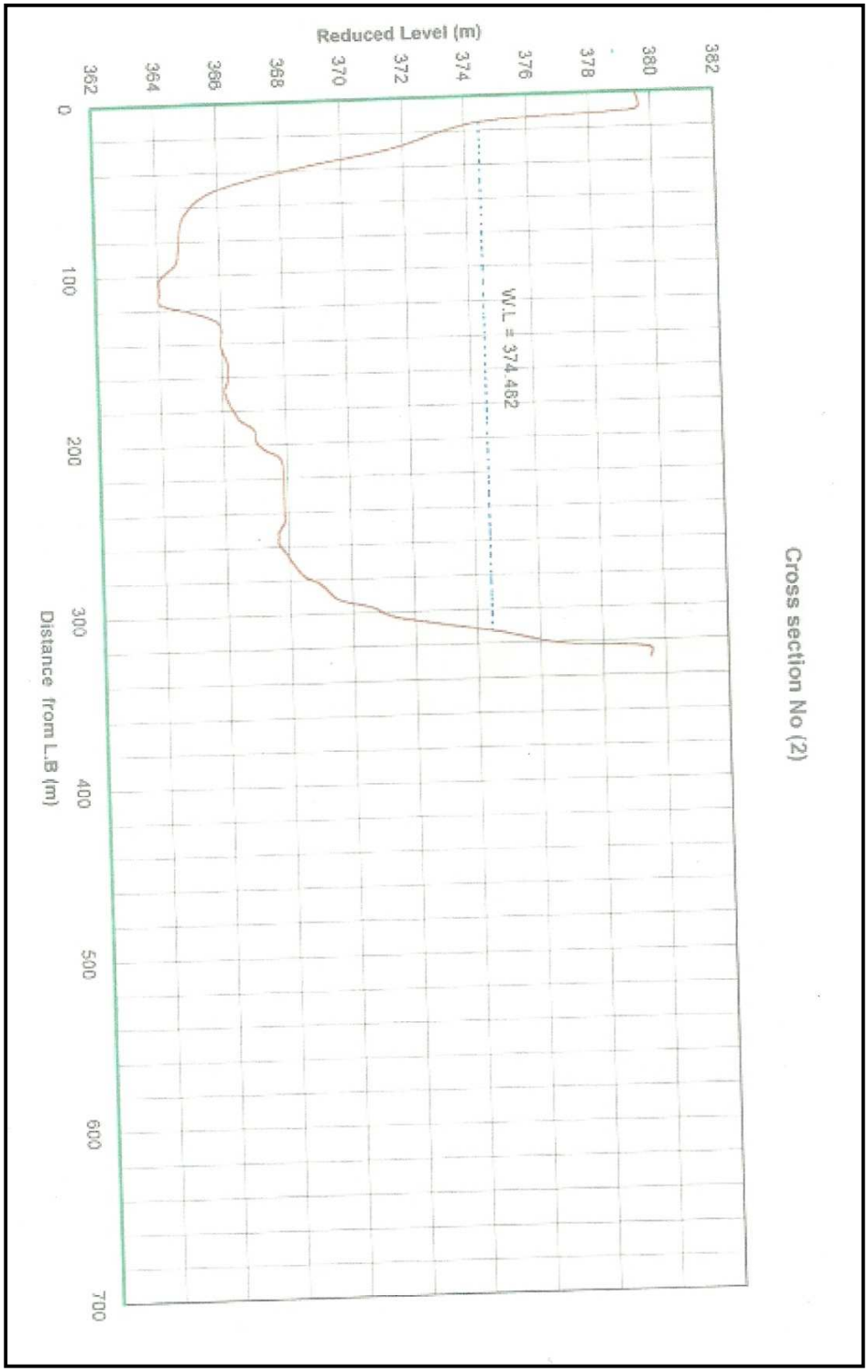
APPENDIX 2: CROSS SECTIONS

The Cross Sections of the main stream of the Blue Nile from the study carried by UNESCO Chairs in Sudan for the Nile River Shores in Greater Khartoum (2002, PP 58-76, Volume 5) as specified below

Cross Section 1

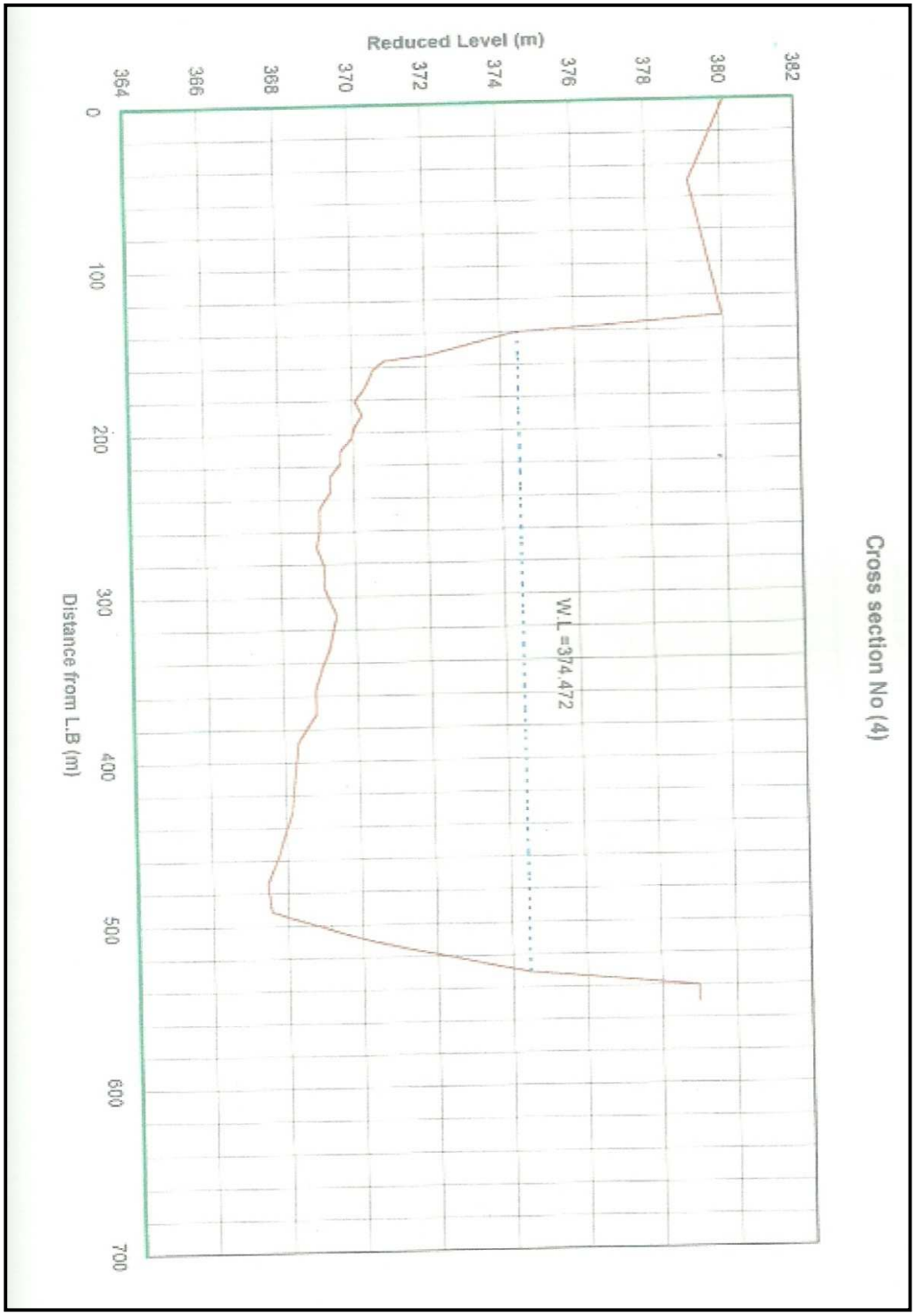


Cross Section 2

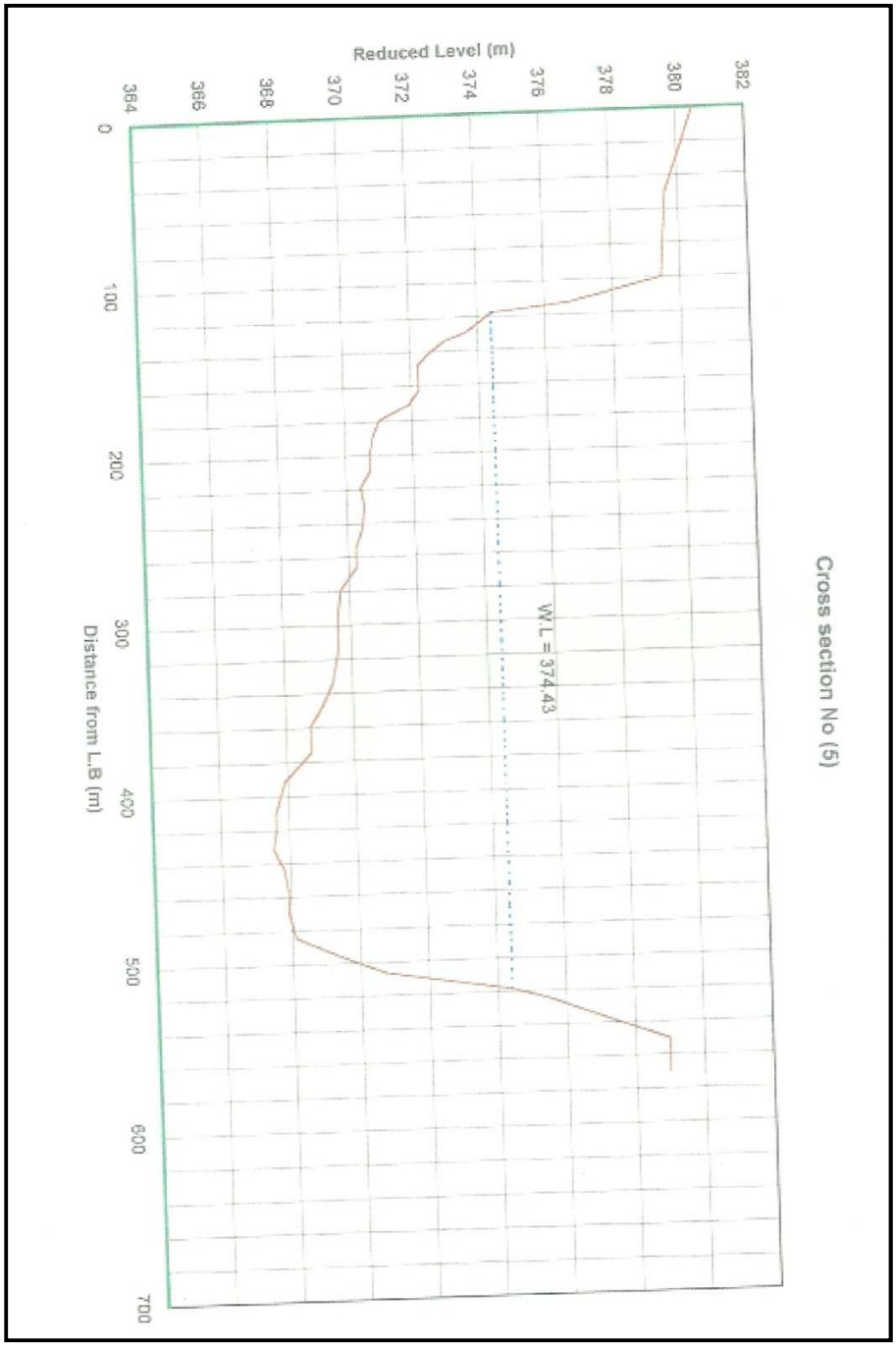


Cross Section 3

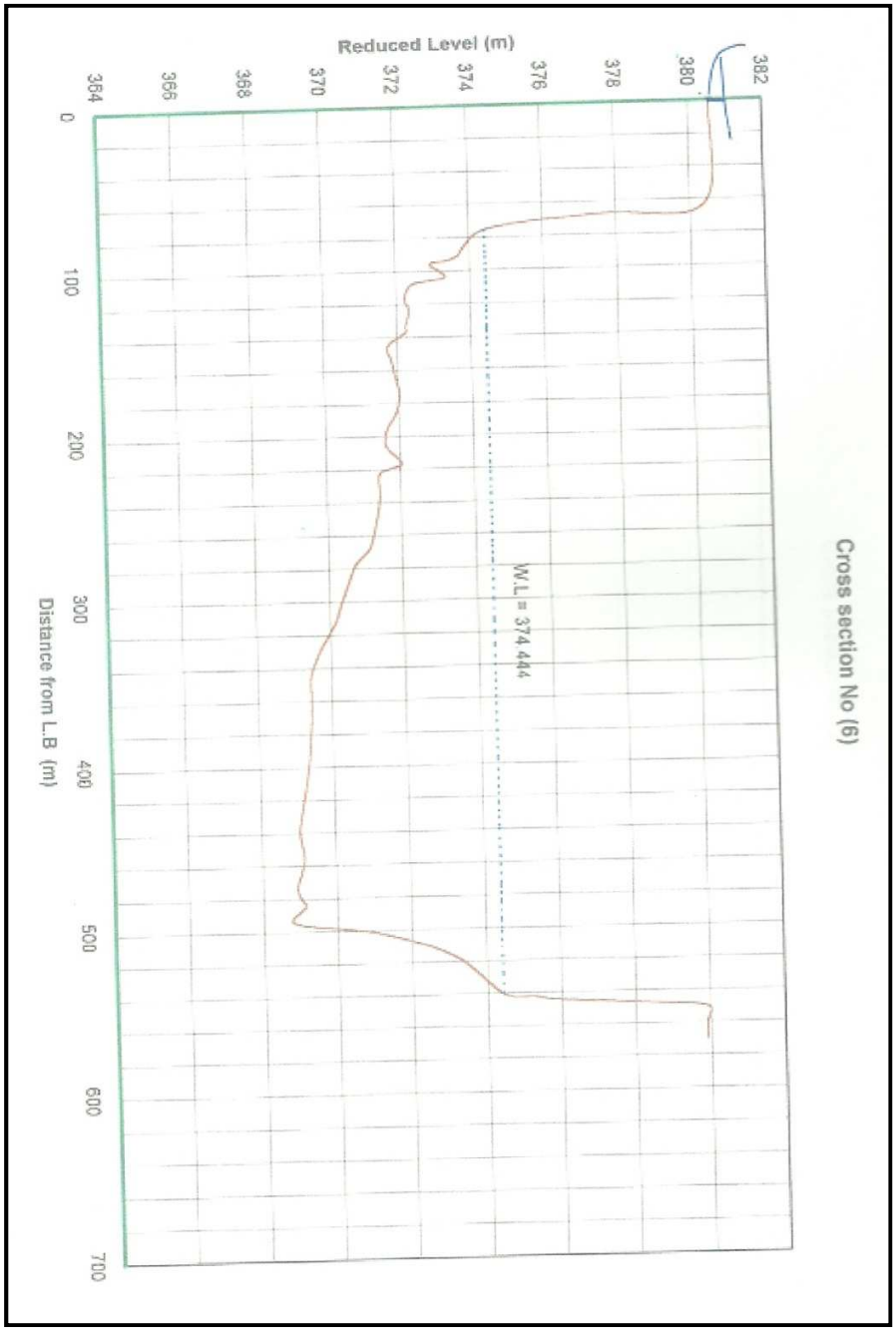
Cross Section 4



Cross Section 5

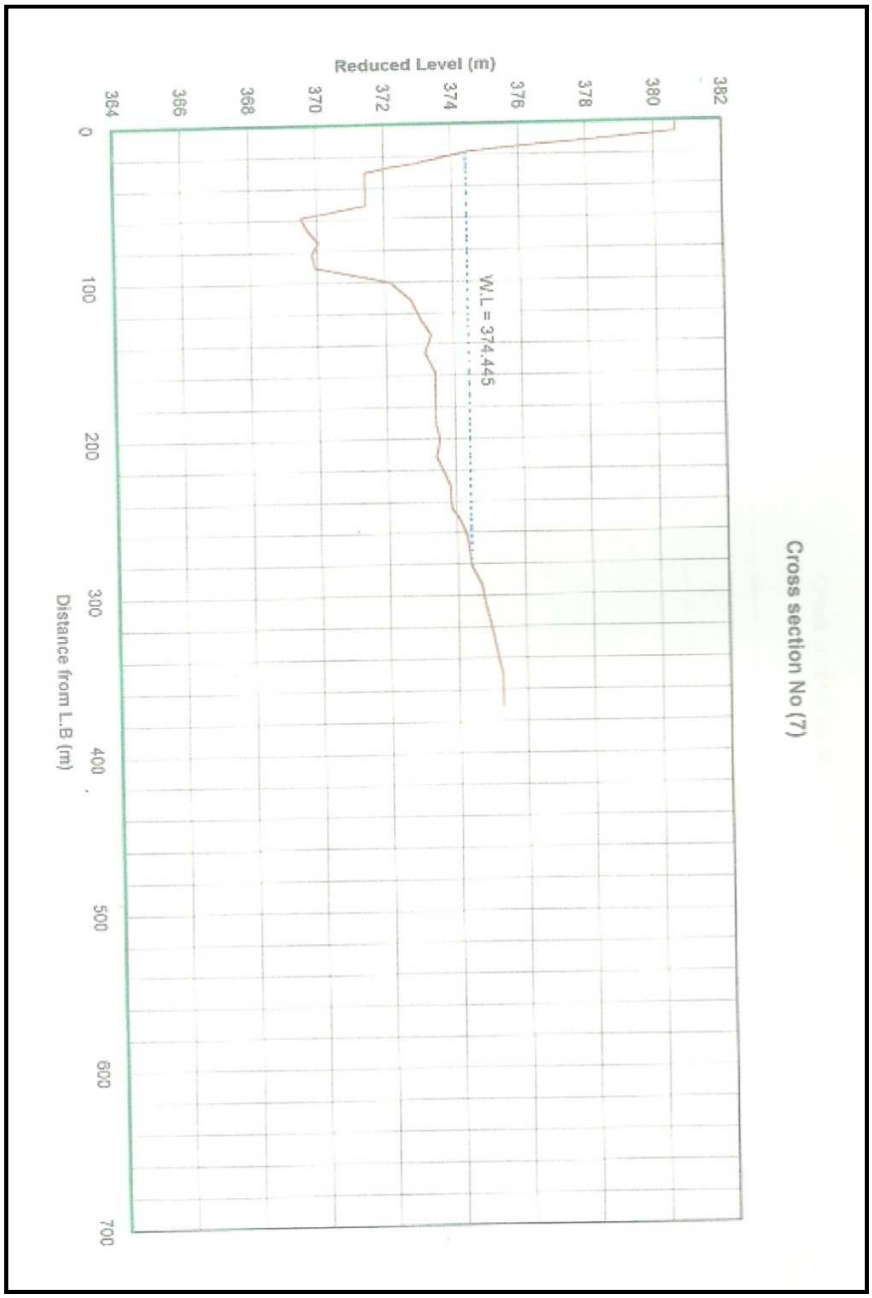


Cross Section 6

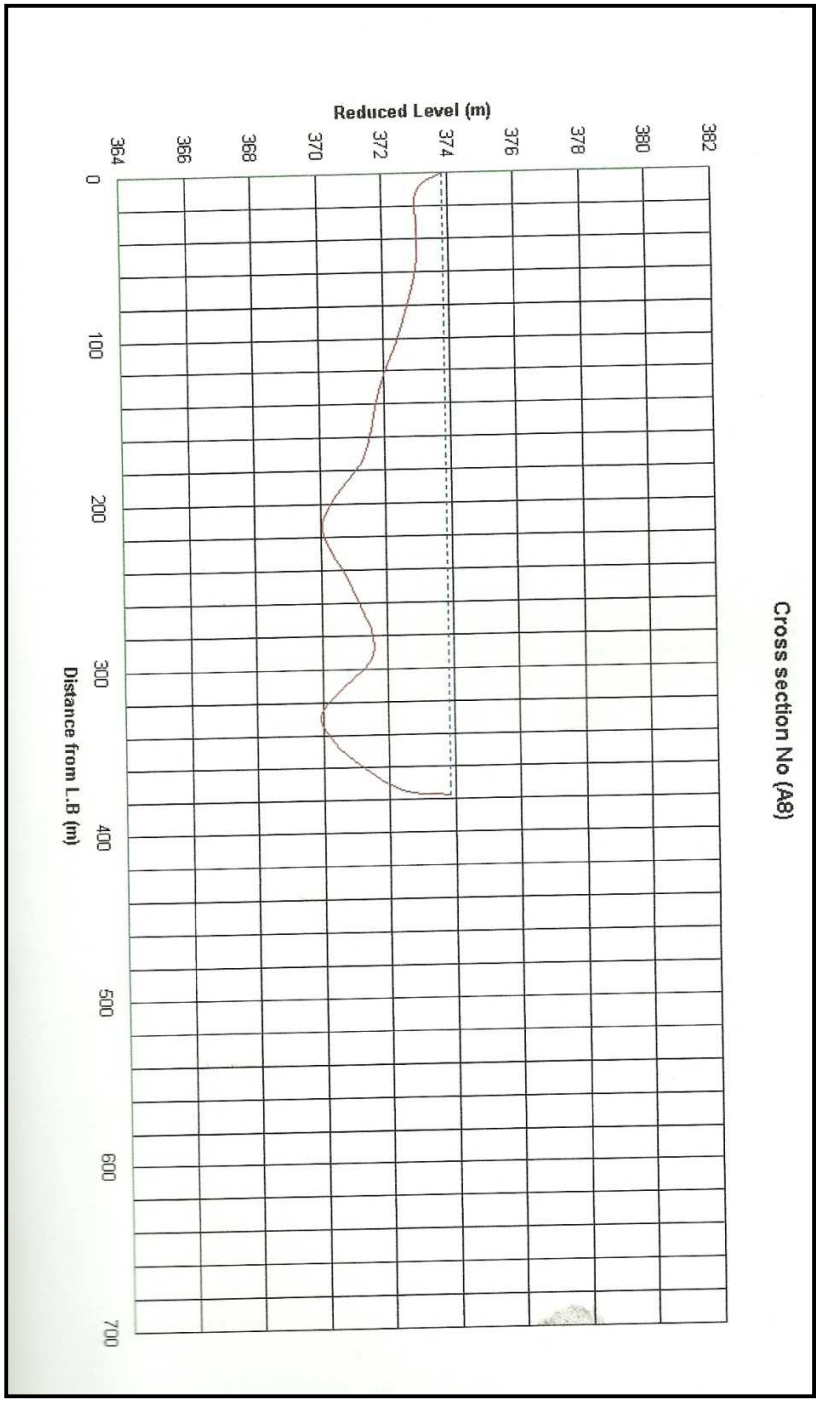


Cross Sections along the Left Blue Nile Branch (same above source)

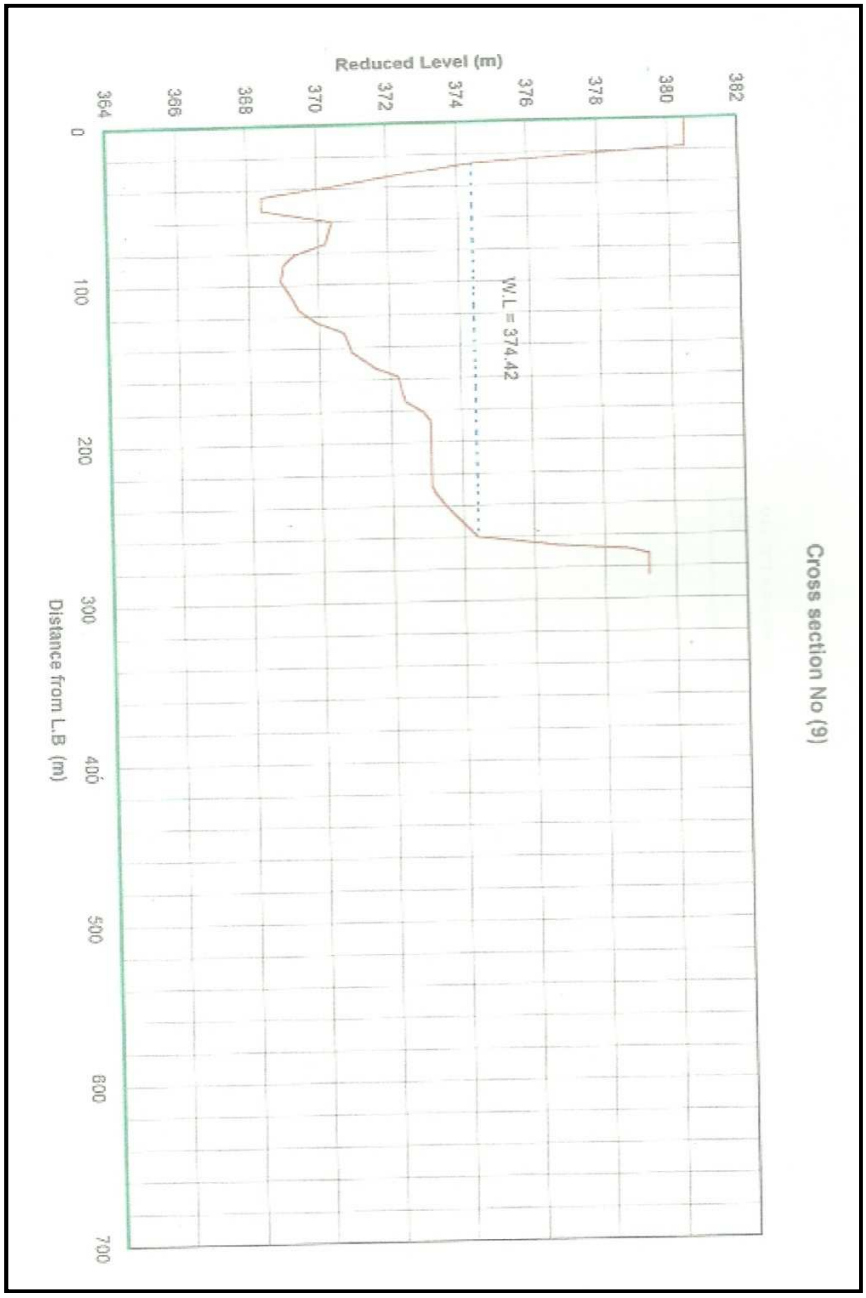
Cross Section 7



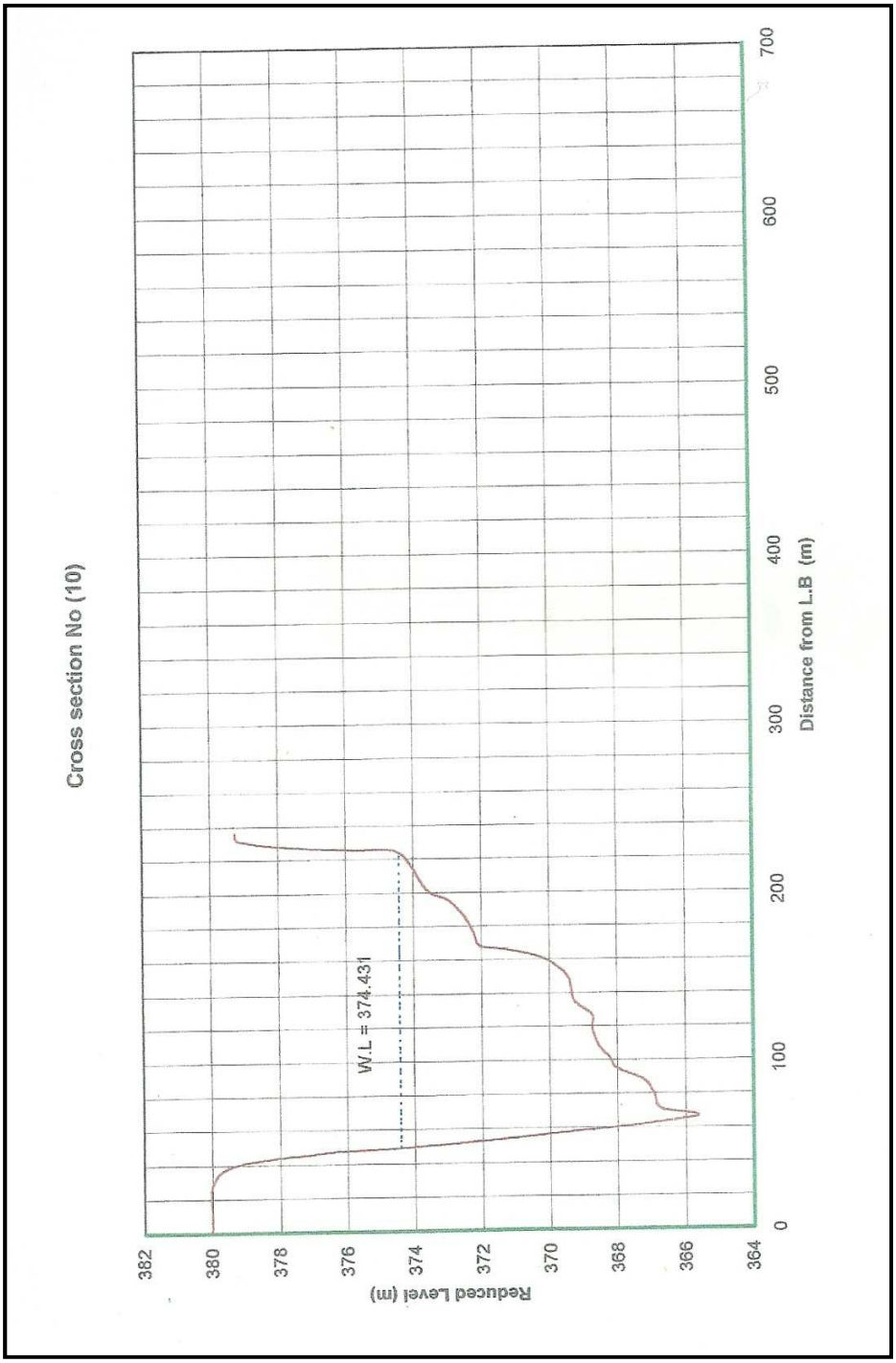
Cross Section 8



Cross Section 9

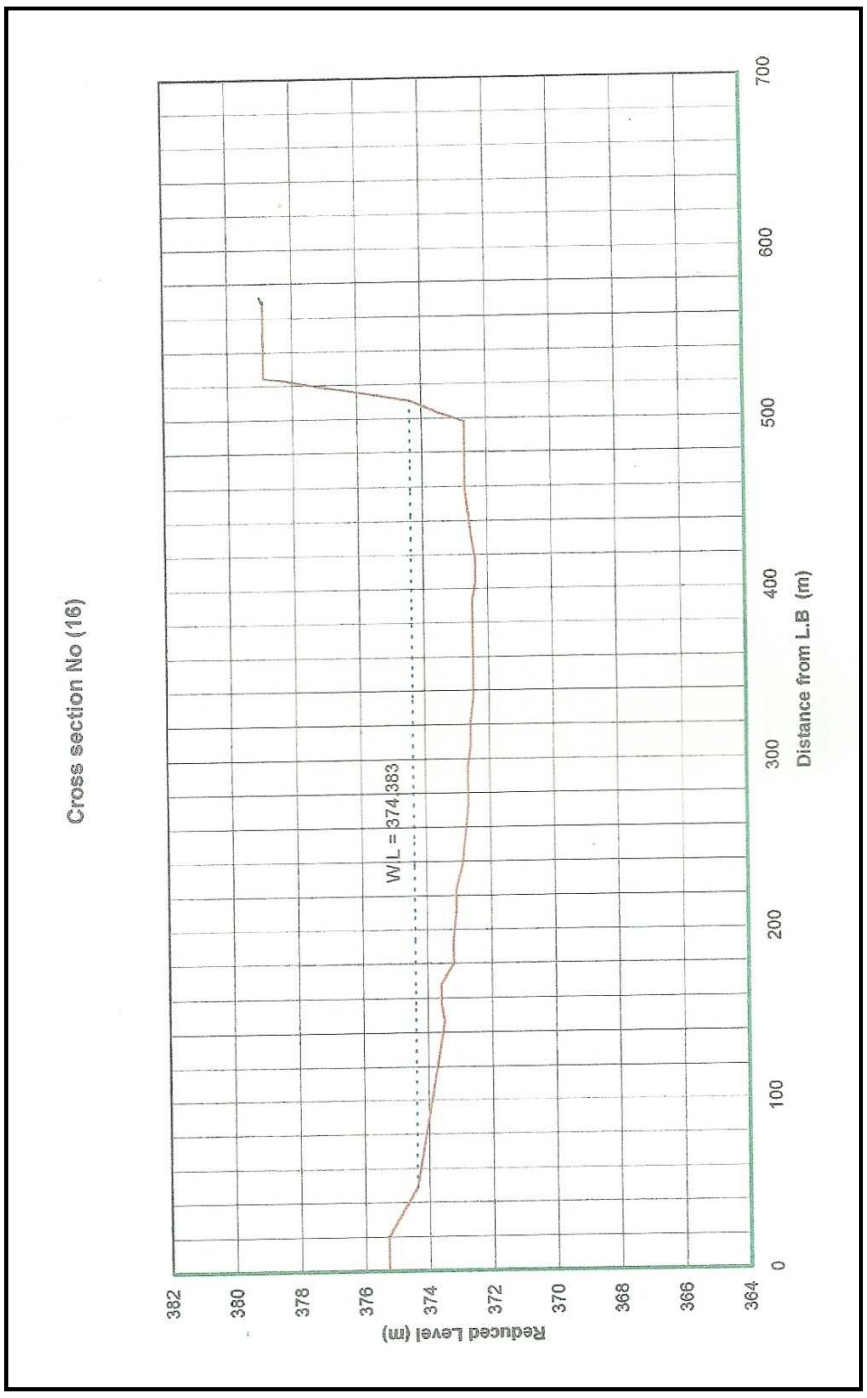


Cross Section 10

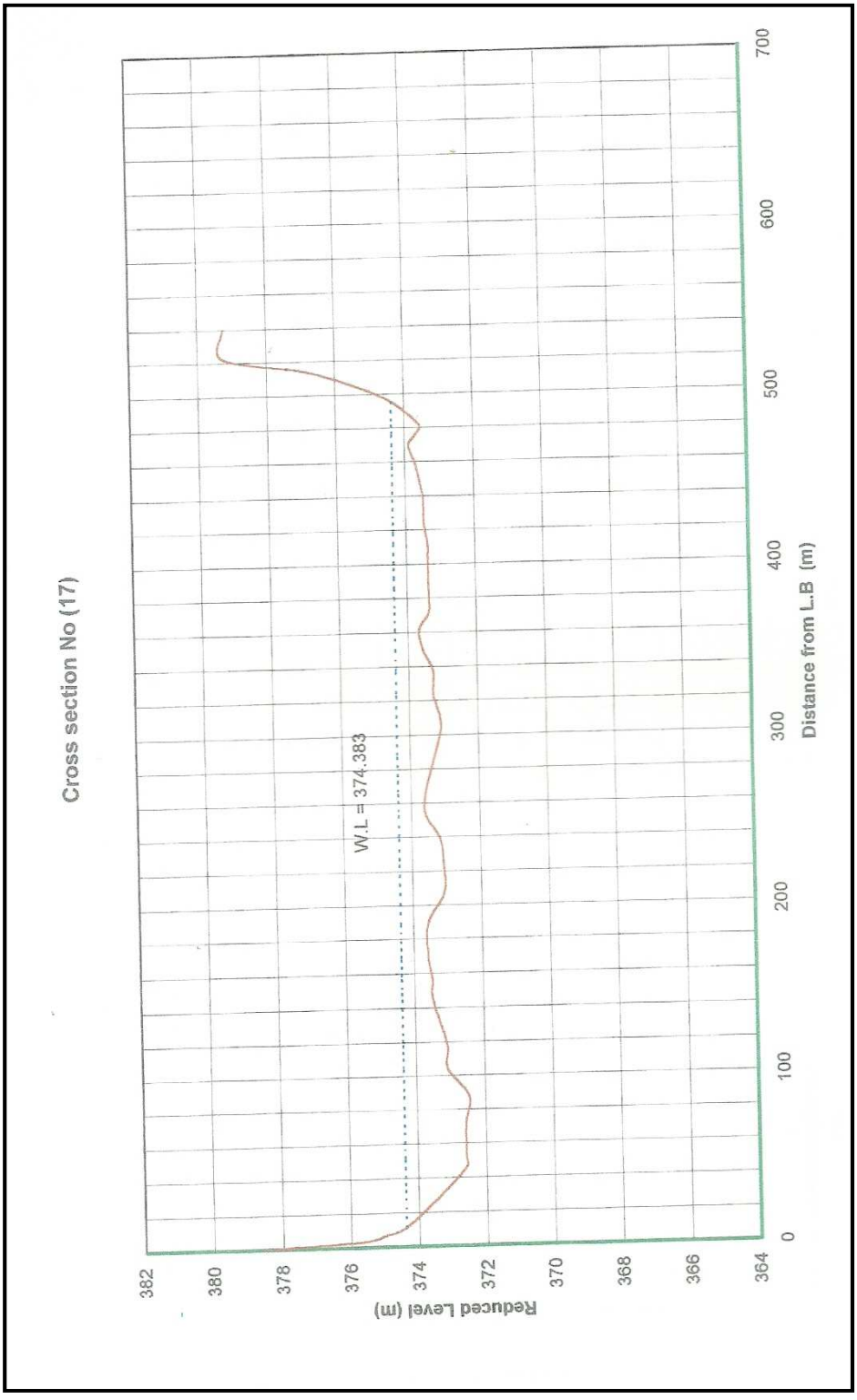


Cross Sections along the Right Blue Nile Branch (same above source)

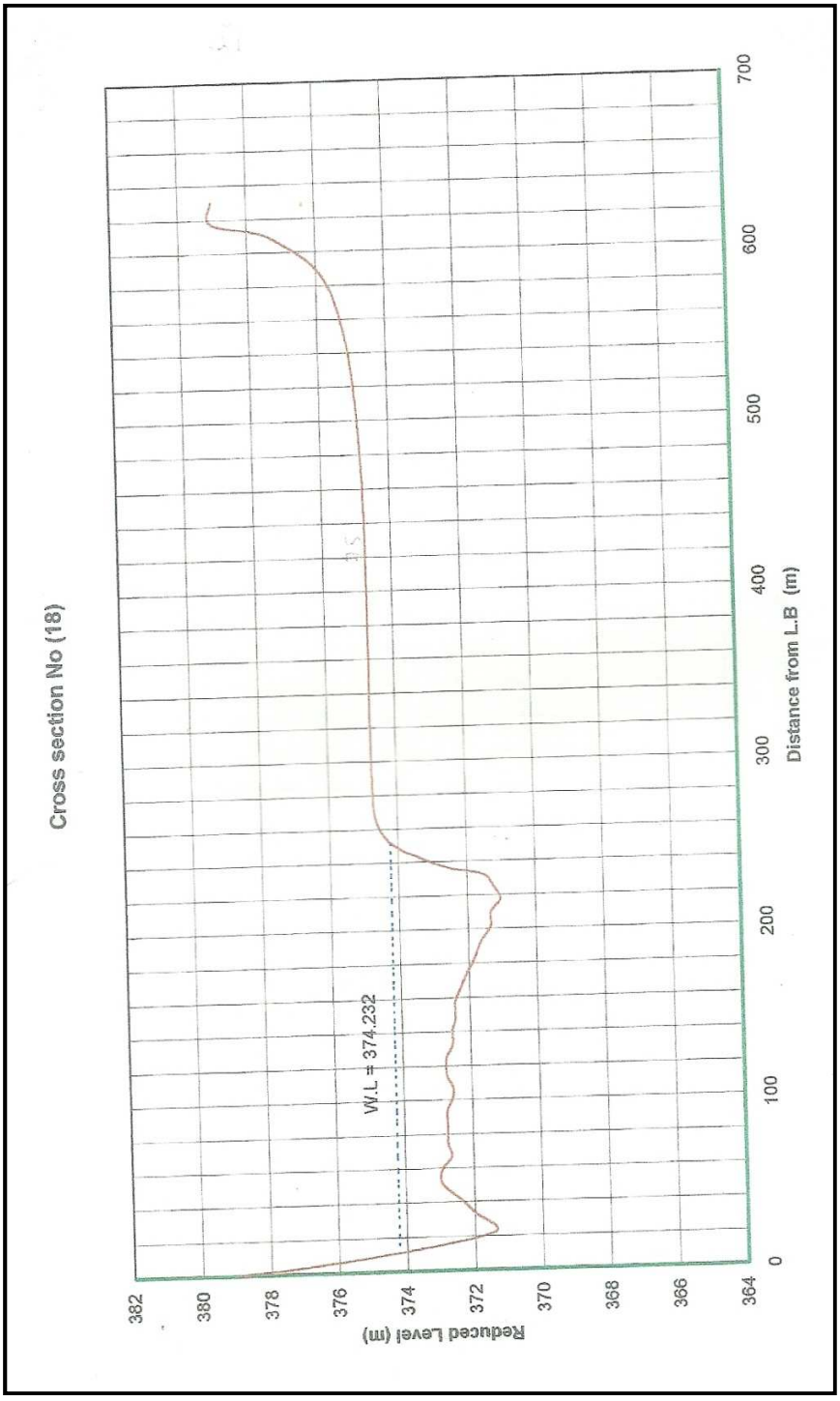
Cross Section 16



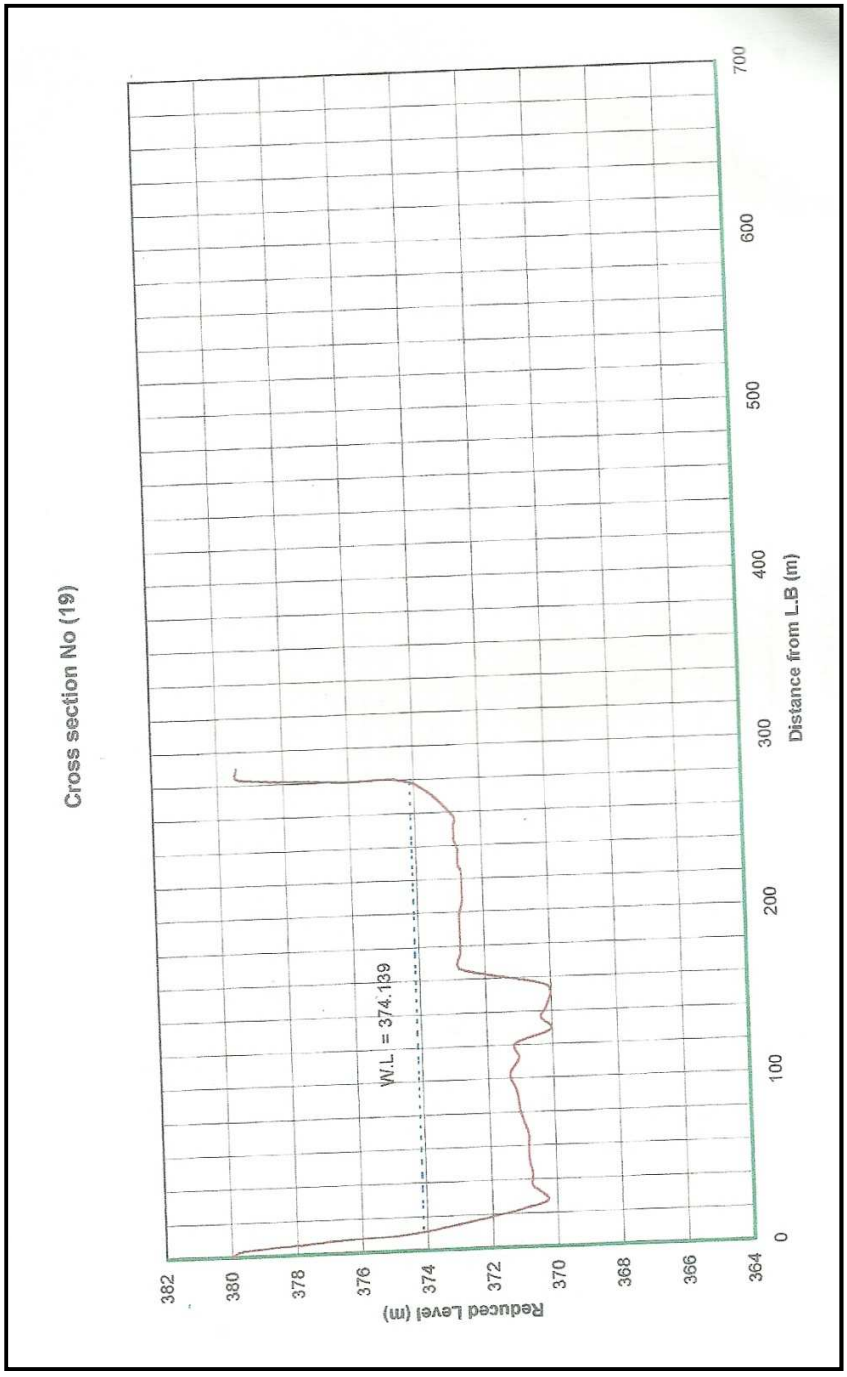
Cross Section 17



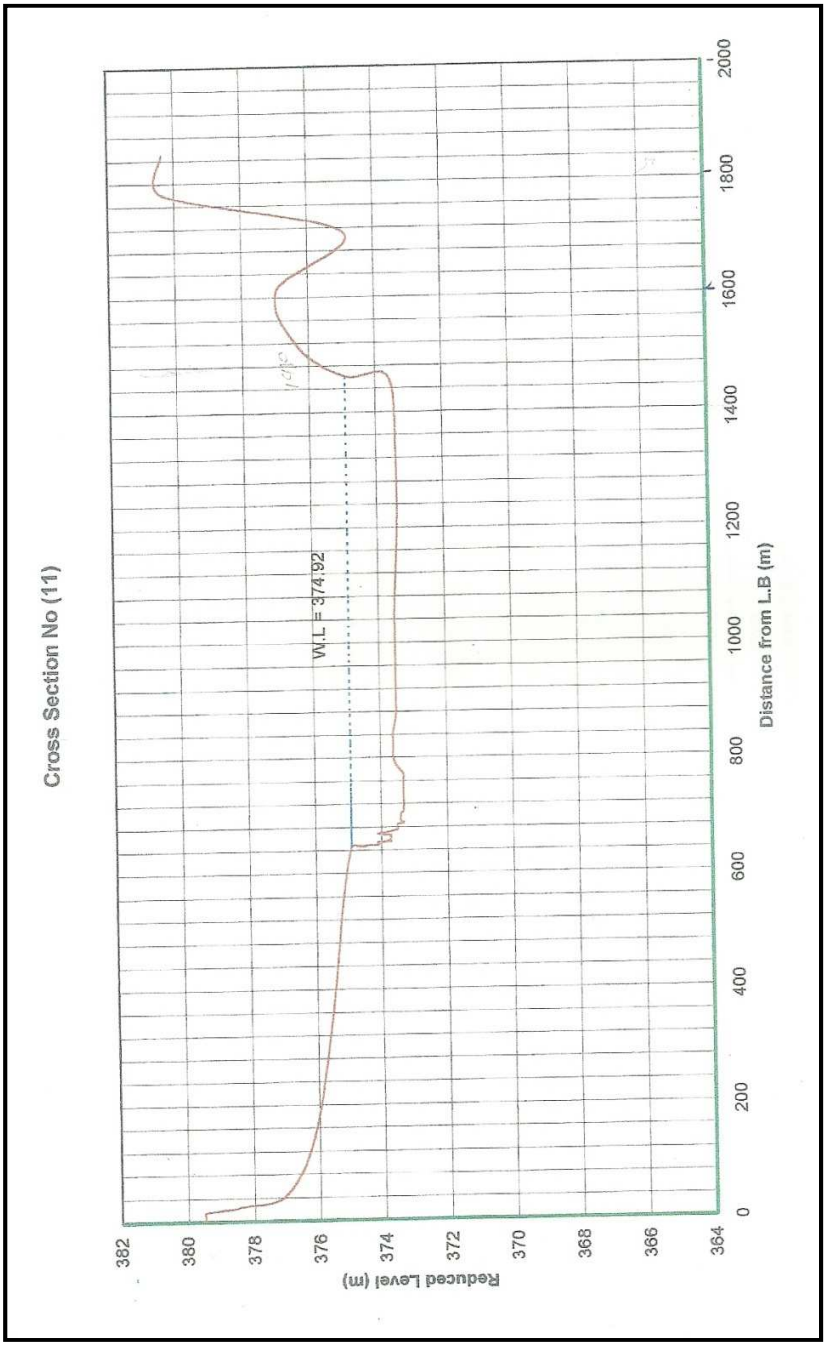
Cross Section 18



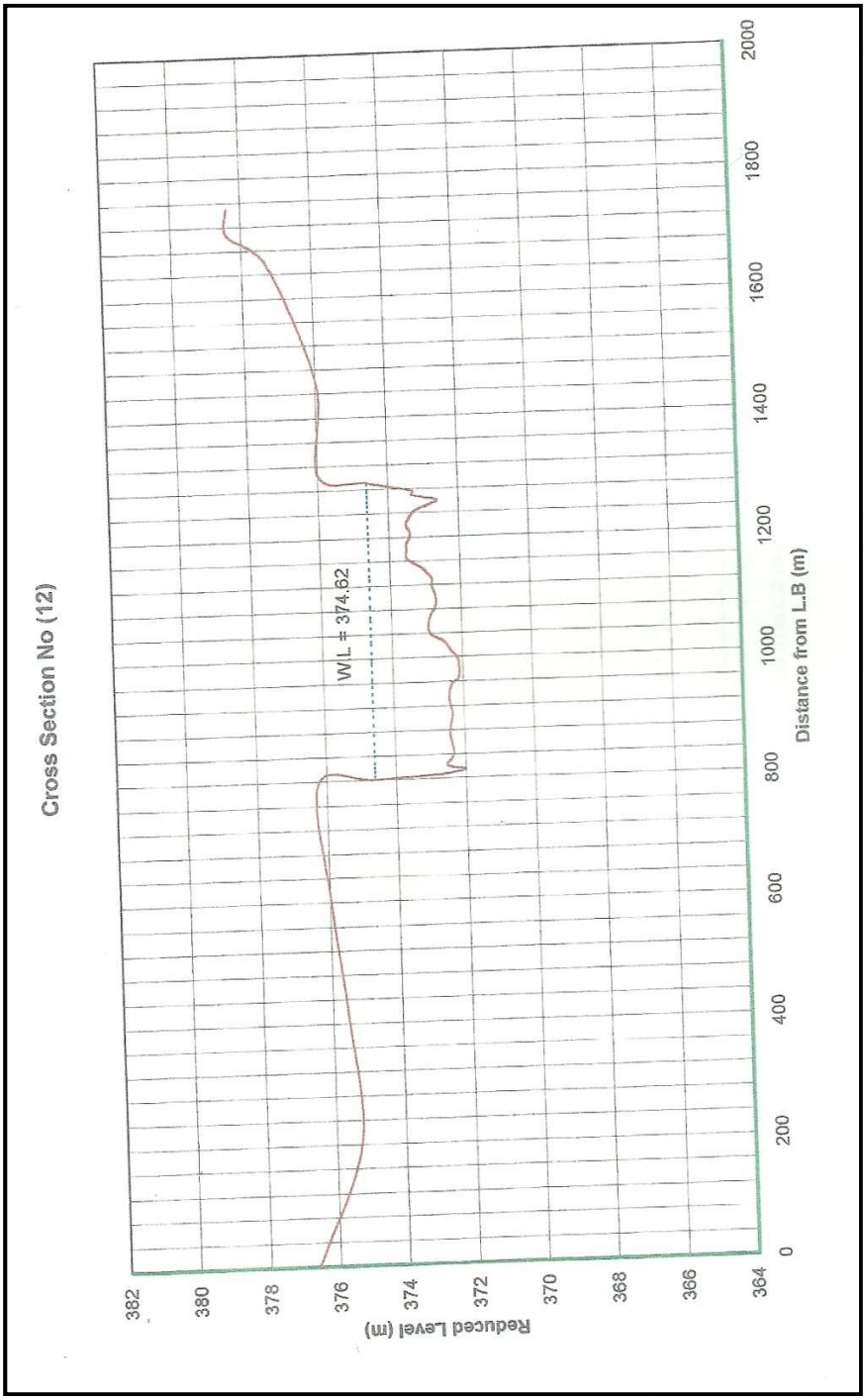
Cross Section 19



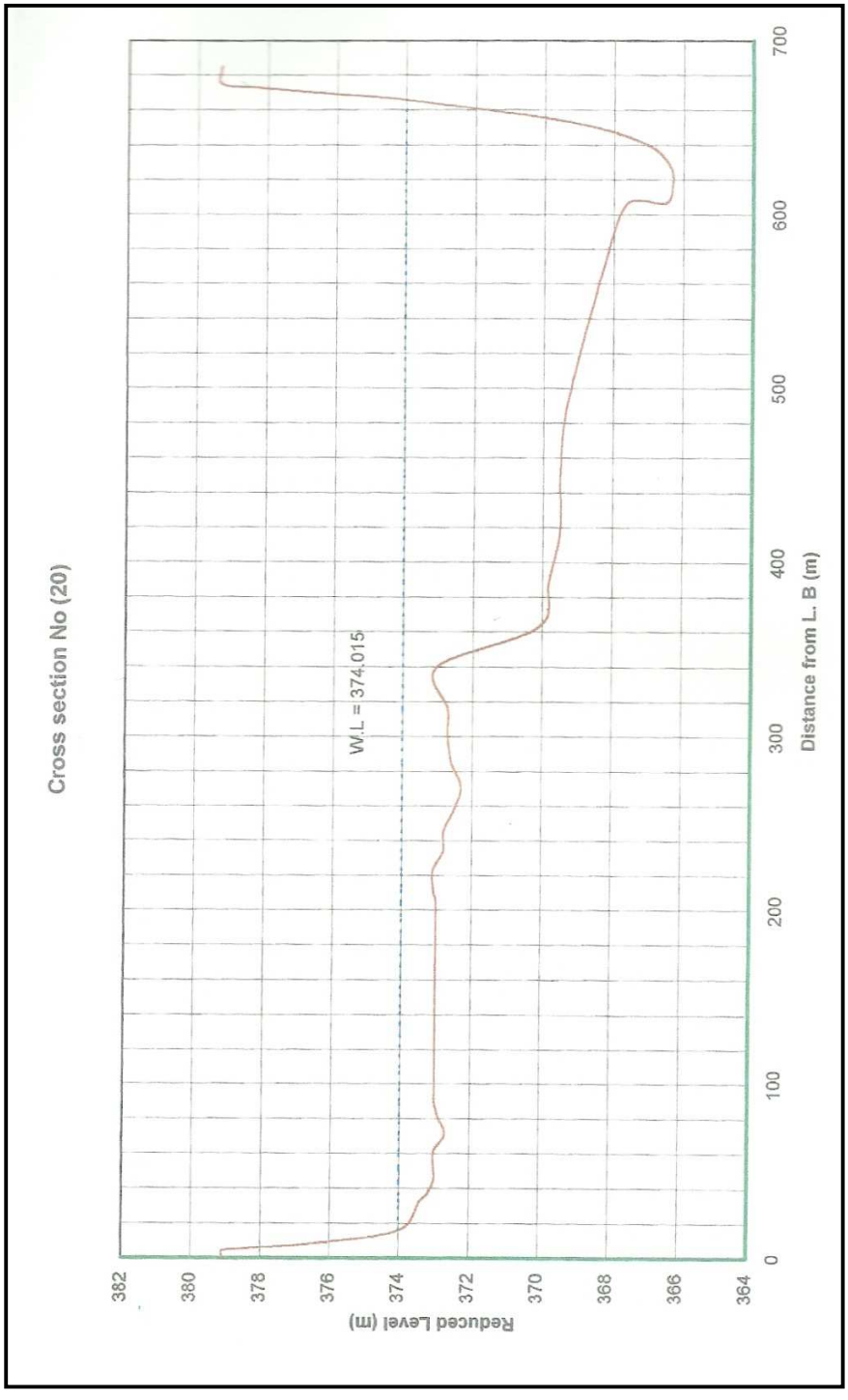
Cross Section 11



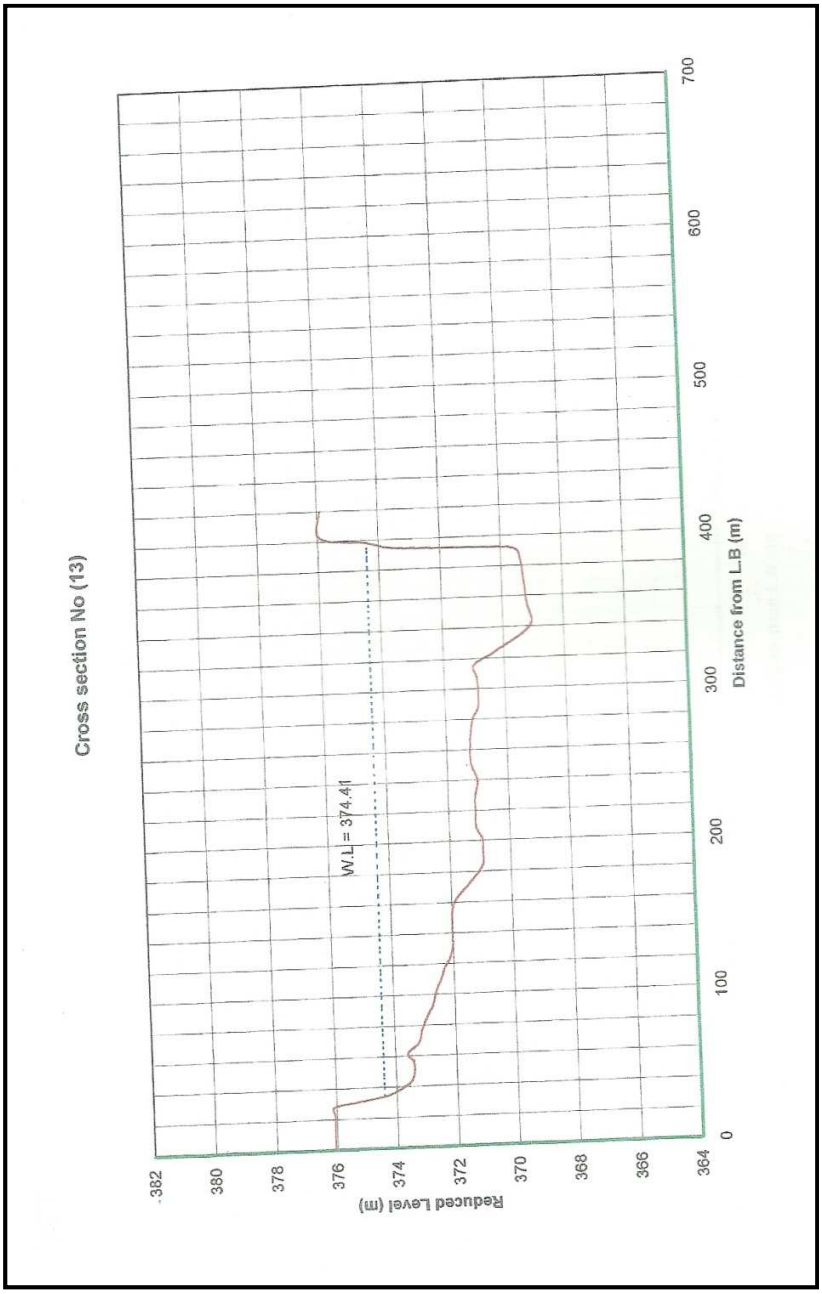
Cross Section 12



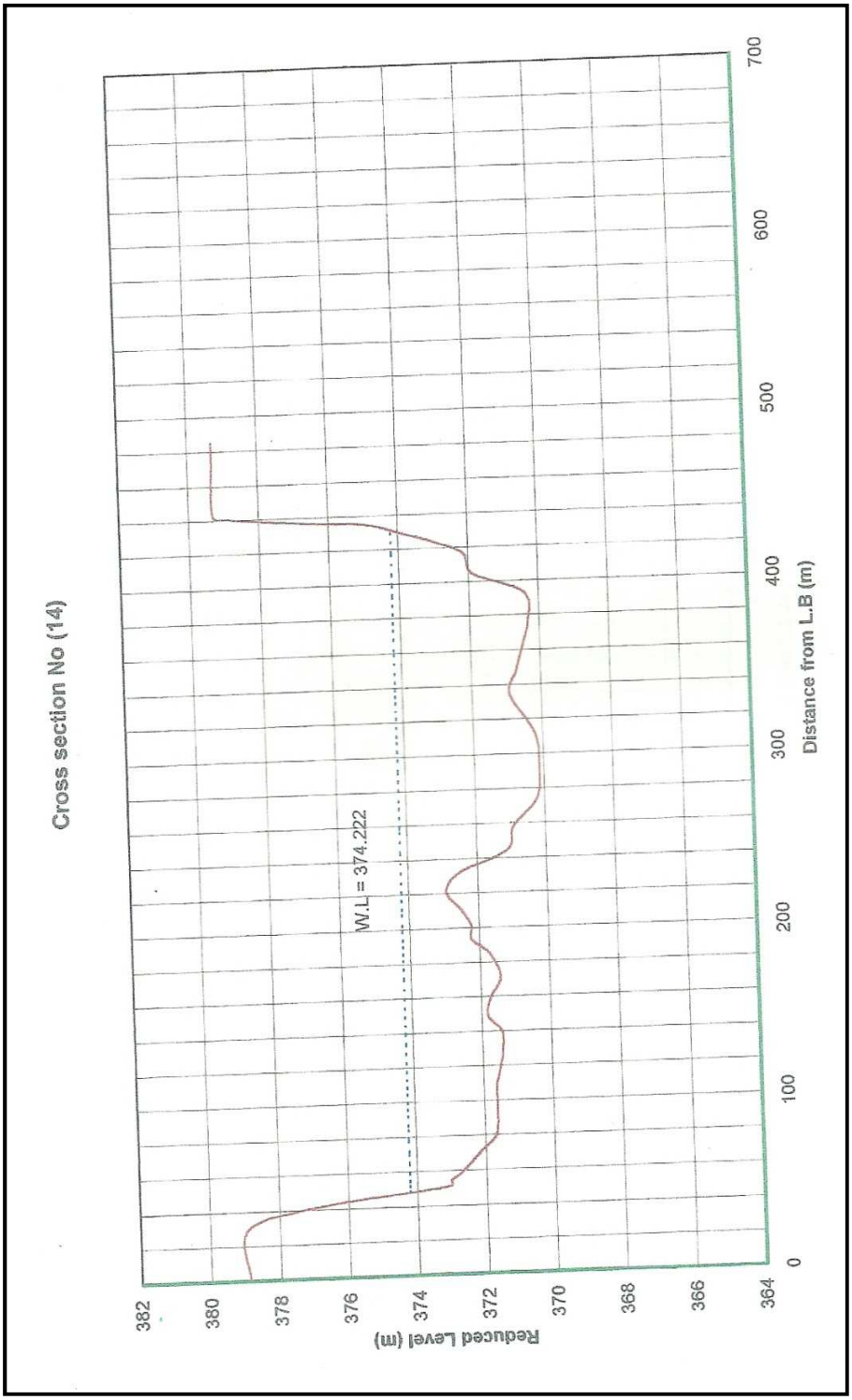
Cross Section 20



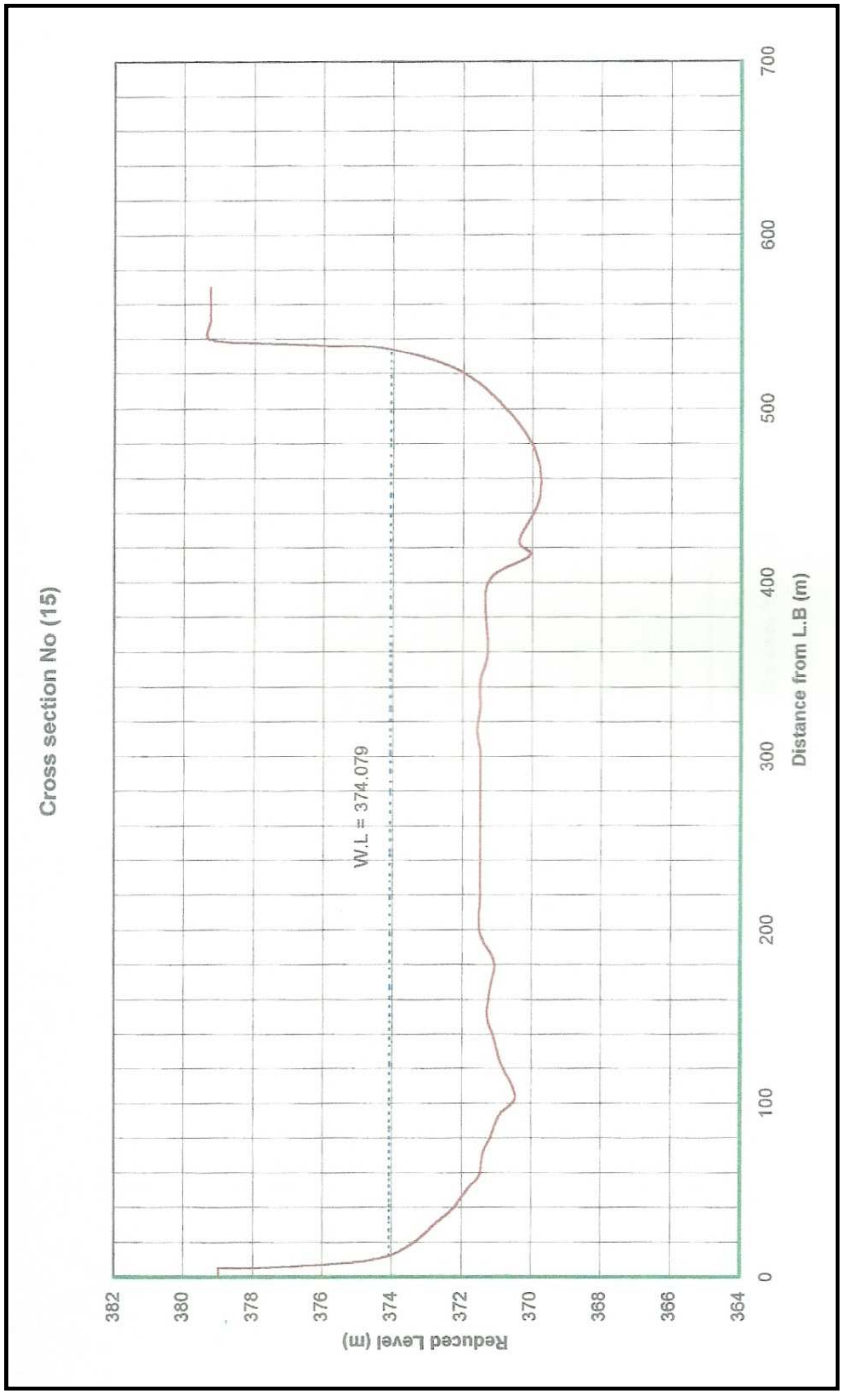
Cross Section 13



Cross Section 14



Cross Section 15



Appendix 3: Land Laws

Land Laws for the study area will be composed from the following laws or acts:

Item	Law Name	Descriptions
1	Land Registration Act	1- Registration of private lands in the study area 2- Registration of lease lands in the study area 3- Registration of government lands in the area
2	Land Types Act	1- Agriculture lands: a- Groof lands b- Booger lands 2- Residential Lands: a- First class b- Second class c- Third class 3- Commercial lands: a- Shops b- Services c- Mix Purposes 4- Industrial Lands: a- Light Industries b- Heavy Industries 5- Mix Use Lands: a- Commercial and Residential b- Services and Residential c- Others mix uses 6- Forested lands: a- Open woodland b- Other Forested Lands 7- Infrastructure Lands: a- Roads b- Telecommunications c- Sewerage and Disposal Land

Item	Law Name	Descriptions
		d- Others 8- Open Water Lands: a- Main Stream of the Nile River b- Nile River Shores c- Nile River Fronts d- Depth of the Nile River Fronts 9- Governmental Lands: a- Public Buildings b- Administration Buildings c- Conservation and Heritage Areas d- Others 10- Recreational Lands: a- Parks b- Open spaces c- Indoor and outdoor sports d- Water based recreation e- Amenities f- Cultural Based Recreation g- Entertainments h- Country side i- Others Recreational Types
3	Land Owners or Holders Act	1- Land owned by the Government (Governmental Lands) 2- Land owned by people (Private Lands) 3- Land owned by the government and rented by one or more than one persons for different used (Lease Lands)
		1- Compensation of private lands per M2 a- Commercial Lands b- Residential lands

Item	Law Name	Descriptions
4	Land Compensation Act	c- Groof agricultural lands d- Booger agricultural lands e- Mix used lands f- Industrial lands g- Others 2- Compensation of Lease lands per M2 for the above different uses
5	Land Reclamation Act	1- Land Transfer Regulations 2- Land Development Regulations for Private Lands 3- Land Development Regulations for Lease Lands 4- Land Development Regulations for Governmental Lands

Appendix 4: Building Regulations

Building Regulations specified different regulations that required for directing and controlling the different types of buildings. This should specify the regulations for the following buildings:

Item	Building and/ or Development Type	Specifications of Building Regulations
1	Commercial Buildings	1- General specifications 2- Drawing Requirements 3- Building height along River Front 4- Building specifications 5- Types of commerce 6- Floor Ratio 7- Distance between blocks 8- Parking area 9- Building Regulations for Greater Khartoum stipulated in 2008 10- Environmental Requirements 11- SDNRF Manual
2	Offices and Flats	1- General specifications 2-Drawing Requirements 3-Building height along River Front 4-Building specifications 5- Floor Ratio 6-Distance between blocks 7-Parking area 8- Type of uses 9- Building Regulations for Greater Khartoum stipulated in 2008 10- Environmental Requirements 11- SDNRF Manual
3	Villas	Same above specifications and requirements
4	Mix Used Buildings	Same above specifications and requirements

Item	Building and/ or Development Type	Specifications of Building Regulations
5	First Class Residential Buildings	1- Plot area 2- Width of roads 3- General specifications 4- Drawing requirements 1- Building specifications 2- Building height along River Front 3- Environmental Requirements 4- Building Regulations for Greater Khartoum stipulated in 2008 5- Technical requirements 6- Residential zones 7- SDNRF Manual
6	Second Class Residential Buildings	Same above specifications and requirements
7	Third Class Residential Buildings	Same above specifications and requirements
8	Light Industrial Buildings	1- Industrial Type 2- Plot area 3- General specifications 4- Drawing requirements 5- Building regulations for Greater Khartoum stipulated in 2008 6- Environmental requirements 7- Technical requirements 8- Environmental Impact Assessment for each industry 9- Industrial zones 10- Development specifications

Item	Building and/ or Development Type	Specifications of Building Regulations
		11- SDNRF Manual
9	Heavy Industrial Buildings	Same above specifications and requirements
10	Recreational Areas	1- Recreational Type 2- Uses 3- General specifications 4- Drawing and technical requirements 5- Environmental requirements 6- Recreational zones 7- Development specifications 8- Environmental Impact Assessment for each recreational type 9- National and local authorities 10- Implementation, monitoring and management of each recreational area 11- Zones of recreational areas in the SDNRF development plan 12- Building regulations for Greater Khartoum stipulated in 2008
11	Governmental Buildings	1- Types of governmental buildings 2- General specifications 3- Drawing and technical requirements 4- Environmental requirements 5- Zones of governmental building in the SDNRF development plan 6- SDNRF Manual 7- National and local authorities 8- Building regulations for Greater Khartoum stipulated in 2008 9- Development specifications

Item	Building and/ or Development Type	Specifications of Building Regulations
		10- Any other requirements
12	Infrastructures	1- Type of infrastructure 2- General specifications 3- Drawing and technical requirements 4- Environmental requirements 5- Development specifications 6- SDNRF Manual 7- National and local authorities 8- Building regulations for Greater Khartoum stipulated in 2008 9- Development specifications 10- Any other requirements

Appendix 5: Building Standards

Building Standards composed of International and Sudan Standards as specified below:

Item	Standard Method	Specifications of Building Standards
1	International Standard	1- British Standards BS for: (i) Materials (ii) Building Specifications (iii) Building Regulations (iv) Building Standards (v) General Requirements (vi) Workmanship standardizations (vii) Any other requirements (viii) Technical Specifications 2- Code of Practice CP Standards for: (i) Steels (ii) Concrete (iii) Bricks (iv) Timber and wood (v) All others building materials (vi) Technical Specifications 3- ISO Standards: For all above specifications and standards 4- European Standards: For different standards as specified in European Standards 5- American Standards: As specified in American Standards 6- African Standards: For different African Standards and Specifications
		1- National Standards: (i) Building Materials Specifications

2	Sudan Standards	(ii) Building Specifications (iii) Building Regulations (iv) Building Standards (v) General Requirements (vi) Workmanship standardizations (vii) Any other requirements (viii) Technical Specifications 2- Local Standards: (i) Local Building Materials (ii) Local Regulations (iii) Local Standards (iv) Technical Specifications (v) Building Standards (vi) General Requirements (vii) Workmanship standardizations (viii) Any other requirements (ix) Greater Khartoum Building Standards stipulated in 2008

Appendix 6: Environmental Impact Assessments EIA

Environmental Impact Assessment EIA for Sustainable Development of the Nile River Front SDNRF at Greater Khartoum will tackle the following elements:

Item	EIA Elements	Specifications
1	Physical Characteristics	1- Population Characteristics 2- Climatic Conditions: (i) Precipitations (ii) Wind (iii) Relative Humidity (iv) Temperature (v) Other Climatic Factors 3- Infrastructure (i) Grey Traffic System (ii) River Traffic System (iii) Railway Traffic System (iv) Air Traffic System 4- River Stabilization Methods (i) Concrete Walls Method (ii) Concrete and Brick Walls Method (iii) Bricks and/or Stone Walls Method (iv) Stone on Dry Pitching Earth Embankments Method (v) Timber or wood piling Method 5- Environmental Situations (i) Greenway System (ii) Blue way System (iii) Ecological System 6- Development Elements (i) Protection of Nile River Banks

Item	EIA Elements	Specifications
		(ii) Development Elements on the Nile River Front 7- Other Physical Elements (i) Water Quality (ii) Sewerage and Disposal System (iii) Energy (iv) Landscape (v) Land use specifications (vi) Others
2	Land Uses	1- Land use type 2- Land use specifications 3- Changes in Land use from the development 4- The impact of the development on land use 5- Assessing of the development on land use 6- Alternative solutions 7- Evaluations and Implementations of the development for the different land uses
3	Characteristics of the main production process	1- Quantitative methods for the development elements 2- Qualitative methods for the development elements
4	Significant effects of the development plan for SDNRF at Greater Khartoum	1- Direct Effects 2- Indirect Effects 3- Short Effects 4- Medium Effects 5- Long Effects 6- Permanent Effects
5	Technical Deficiencies or Lack of Information of the Development Plan	1- Lack of Statistics Information 2- Lack of Plans 3- Lack of technical data

Item	EIA Elements	Specifications
		4- Lack of Survey 5- Lack of public participations 6- Lack of public awareness 7- Feed back information
6	Outline the main alternatives and their impact on environment	1- Alternative Development Plans 2- Evaluations of each Alternative Development Plan on Environment 3- Selection of the best alternative development plan
7	Technical Summary of SDNRF at Greater Khartoum	1- Description of the Selective Development Plan 2- Technical Specifications of the Selective Development Plan 3- Summary of the assessments and evaluations of the Selective Development Plan on environment 4- Summary of Implementation Process for the development elements 5- Summary of Finance for the different development elements 6- Summary of Managements for the development plan

Appendix 7:

Sustainable Development of the Nile River Front SDNRF Manual

The Sustainable Development of the Nile River Front in Greater Khartoum 'SDNRF Manual' composed from those information that describes the development plan for the Nile River Front as specified in below table:

Item	SDNRF Elements	Specifications of SDNRF Elements
1	Nile River Shores in Greater Khartoum	1- Blue Nile River Shores 2- White Nile River Shores 3- Main Nile River Shores
2	Current Situations of the Study Area	1- Historical background for the study area 2- Specifications of the current situation of the sixteenth Nile River Shores 3- Information about Cairo, Egypt as similar case study 4- Barriers and constraints restricted the development of the Nile River Front
3	Information about Cairo, Egypt as similar case study	1- Historical background about Cairo Transformation and development 2- Current situations of Nile River Shores in Greater Cairo 3- Development Plan for the Nile River Front in Greater Cairo 4- Water Management of the Nile River in Egypt due to the Aswan High Dam
4	Development Elements for the Nile River Front in Greater Khartoum	1- Stabilization Methods of the Nile river Banks (i) Concrete Walls Method (ii) Concrete and Brick Walls Method (iii) Bricks and/or Stone Walls Method (iv) Stone on Dry Pitching Earth Embankments Method (v) Timber or wood piling Method 2- Architectural Issues on Nile River Front

Item	SDNRF Elements	Specifications of SDNRF Elements
		(i) Development Plan for Nile River Front (ii) Greenway System (iii) Landscape (iv) Environmental issues (v) Socioeconomic issues
5	Technical Specifications	1- Summary of the Development Plan for Sustainable Development of the Nile River Front in Greater Khartoum 2- Summary of the impact of the development on the environment 3- Summary of technical drawings for the development of the Nile River Front in Greater Khartoum 4- Summary of technical specifications
6	Laws and Building Regulations	1- Summary of Laws 2- Summary of Building Regulations 3- Summary of Building Standards
7	Strategy for the development plan	1- National strategy for the development of the Nile River Front in Greater Khartoum 2- Local strategy for the development of the Nile River Front in Greater Khartoum
8	Implementation Programmes	1- Long term programme 2- Medium term programme 3- Short term programme
9	Authorities	For the coordination between the different authorities it is preferred to establish Initiative Body for the Sustainable Development of the Nile River Front SDNRF in Greater Khartoum
		1- Contributions of National and Local resources

Item	SDNRF Elements	Specifications of SDNRF Elements
10	Finance of the Development Elements	2- Contributions of the different Sudan provinces 3- Contributions of international financers such as World Bank, European Unions, etc 4- Contributions of Local Developers 5- Contributions of National Developers
11	Management	Management of the development will be by the Initiative Body
12	Monitoring	Monitoring also will be under the responsibility of the Initiative Body
13	Public Participation	1- Public Participations 2- Public Awareness 3- Feedback about the development plan
14	Barriers and constraints restricted the development	1- Lack of water management 2- Lack of local materials 3- Lack of local skills 4- Lack of economic situations and poverty 5- Lack of laws and regulations 6- Lack of public awareness
15	Suggestions of Solutions for Barriers and Constraints	1- Construction of dams and river echo system 2- Construction of local Industries 3- Training 4- Economic Improvement 5- Stipulation of Laws 6- Increase of public awareness

Bibliography

References

Adam, W.A. & Gibbs, R.J. (2004) *Natural Turf for Sport and Amenity: Science and Practice.* 3rd ed. Cambridge: University Press.

Abdel Rhman, A. (2004) *Rehabilitation of Historical Cairo*. PhD thesis, University of Cairo in Egypt.

Abley,I. & Heartfield, J. (2001) *Sustainable Architecture in the Anti-Machine Age.* 1st ed. John Wiley and Sons Press.

Abu Loughod, A. (1971) *History of Egypt.* 1st ed. Cairo: Cairo Press.

Abusleem, M. (1970) *History of Sudan.* 2nd ed. Sudan: Khartoum International Press.

Adrin, P. (2004) *Planning and Design Strategies for Sustainability.* 1st ed. Oxford: Architectural Press.

Albert, R.A. (1971) *Anatomy of Parks.* 1st ed. USA.

Andreas, F. (1973) *Reader in Planning Theory*,vol.5. 1st ed. Pergamon International Press.

Andreas, F. (1973) *Urban and Regional Planning*, vol.7. 1st ed. Pergamon International Press.

Author Survey and Observation Results.

Awan, S.G. (1980) *History of Sudanese Tribes Roots.* 2nd ed. Sudan: Khartoum International Press.

Aymen, H. (May, 2000) *Site Planning for Cairo Waterfront.* PhD thesis, University of Cairo in Egypt.

Baker, N. & Steemers, K. (2000) *Energy and Environmental in Architecture- A technical design guide.* 2nd ed. E&F N Spon.

Barbara, S. (2002) *Garden by the Sea*. 1st ed. Frances Lincoln Limited.

Barton, H., eds. (2000) *Sustainable Communities- The Potential for Eco- Neighbourhoods.* Earthscan Press.

Benerolo, A. (1980) *Historical Cairo*. 2nd ed. Cairo National Press.

Bianca, S., eds. (2000) *Urban form in Arab world- Past and Present.* London: Thames and Hudson.

Cantacuzino, S., eds (1985) *Architecture in continuity: building in the Islamic world today: Aga Khan Award for Architecture*. New York: Aperture Press.

China Architecture (2007) *Commercial and Building Areas.*

Doxiadis (1958) *Greater Khartoum Structural Plan*. Plan No 33.

Doxiadis (1992) *Greater Khartoum Structural Plan*. Plan No 25.

Francisco, A.C. eds. (1992) *New Architecture for Sports facilities.* Spain: Francisco Asensio Cerver.

Grattion, J. & Taylor, E. (1985) *Sports and Recreational development.* London: E& FN Spon Ltd.

Geological Department in Sudan (2009) *Annual Report about Resources in Sudan.* University of Khartoum Press.

Greater Cairo Province (2007) *Annual Report about Traffic in Cairo Province.*

Harlow, E. & Longman, G. (1988) *Economic of Leisure Services Management.* 1st ed. UK limited.

Hamid, M. A. (2008) *Holly City Old Historical Cairo.* PhD thesis, University of Ain Shams in Egypt.

Houghton,E. (1978) *Architecture and Urban Design.* 1st ed. England: Construction Press.

Hultzman, W.Z. et al. (1993) *Planning Parks for People.* 1st ed. London: Printed London Press.

Human Right Watch (2007) *Report about Immigration in Sudan*.

Jesssica, C.T. (2006) *40 Architects under 40*. 1st ed. Lord National Press.

Jubenville, B.W. et al. (2004) *Outdoor Recreational Management Theory and Application.* 1st ed. Architectural Press.

KSSC [Khartoum State Sewerage Corporation]. (7Jan. 2008) *General Report about Sewerage System in Greater Khartoum.* Khartoum, pp. 8-12.

KST [Khartoum Study Team]. (July 1999) *Study for Developing the Central Business District CBD area in Khartoum.* Khartoum: University of Khartoum Press.

KSWC [Khartoum State Water Corporation]. (Jan 2008] *General Report about Water Quality in Greater Khartoum.* Khartoum, pp. 33.

Lewis, K. (1970) *Town and Country Planning.* 3rd ed. London W1: The Estates Gazette Limited 151 Wardour Street.

Lodewijk, B. (1995) *Designing Parks.* 2nd ed. Amsterdam: Natural Press.

Mafit, A. (1976) *Greater Khartoum Structural Plan.* Plan No 25.

MA METROLOGICAL AUTHORITY in Sudan (2001) *Records for Climate in Khartoum and Khartoum North from (1971-2000).* Khartoum, pp.30-33.

MC MINISTRY OF COMMUNICATION in Sudan (2009) *Annual Report about Telic-communication System in Greater Khartoum.* Khartoum, pp. 21-30.

ME MINISTRY OF EDUCATION in Sudan (2009) *General Report comparing the education in the year 1999-2000 and the year 2007-2008.* Khartoum, pp. 5-19.

MFNE MINISTRY OF FINANCE AND NATIONAL ECONOMY in Sudan (Dec. 2008) *The Sudan annual Budget for the year 2009.* Khartoum, pp. 7-9.

MH MINISTRY OF HEALTH in Sudan (Dec.2007) *General Report about public and private hospitals in Greater Khartoum.* Khartoum, pp. 8-9.

MI MINISTRY OF INDUSTRY in Sudan (June 2008) *Planning for; Heavy and Light industries in Greater Khartoum.* Khartoum, pp. 23-50.

MI MINISTRY OF IRRIGATION in Sudan (2002) *Records of the Nile River for 50 years.* Khartoum, from 1950- 2000.

MTC MINISTRY of TRADE and COMMERCE in Sudan (2008) *Report about the Trade Balance in Sudan, exports and imports materials.* Khartoum, pp. 7-12.

NAIOP [National Association of Industrial and Office Parks], eds. (1991) *Leisure in the 1990s.* 1st ed. London.

NAIOP [National Association of Industrial and Office Parks], eds. (1991) *Amenities for 1990s.* 1st ed. London.

NAIOP, eds. (Nov 2002) *Sustainability at the Cutting Age.* UK National press.

Nalson, Y. (1976) *Leading Issues in Economic Development.* UK: Oxford University Press.

NBI [Nile Basin Initiative]. (2003) *Annual Report about Nile Countries.*

Neil, R. (1992) *Recreational Planning and Development.* 1st ed. London: Macmillan Press.

Parker, D.J. & Penning, R. (1980) *Water Planning.* 2nd ed. London: George Allan & Unwin Ltd.

PPC [Physical Planning Corporation in Egypt]. (2003) *Development Plan for Greater Cairo.* Cairo, pp. 31-33.

PCC [Population Census Centre in Sudan]. (2009) *the Fifth Population Census Results of Sudan which held in May 2008.* Khartoum, pp. 20-70.

Rutledge, A. (1971) *Anatomy of Parks.* 3rd ed. USA: Grow Hill Press.

Seabrook, W. & Miles, C.W. (1993) *Recreational Land Management.* 2nd ed. National Press.

SD SURVEY DEPARTMENT in Sudan (2005) *Nile River Maps.* Khartoum, Maps 7, 19, 22 and 30.

SHR [Sudan Historical Records]. *General Historical Records.*

Thomas, R., eds. (2002) *Architecture and the urban Environment- A vision for the new age.* Architectural Press.

UB [University of Birmingham in UK]. (July 2003) *study for Sustainable Management of Urban Rivers Floodplains.* UK, pp. 13 -14.

UC [University of Cairo in Egypt]. (March 2005) *Study for Developing Nile Riverfront in Greater Cairo.* Cairo, vols. 1-3.

UKFA [University of Khartoum, Faculty of Agriculture in Sudan]. (2009) *Vegetation Types on Nile Riverfront in Khartoum.*

UN (2005) *Environmental Sustainability Index ESI.* Table 10.

UNESCO- CWR [UNESCO Chair in Water Resource in Sudan]. (August 2002) *Study for Developing Nile Riverfront in Greater Khartoum.* Khartoum, vols.1-5.

Usama, A. A. (2005) *Sustainability of Residential Zones in Greater Cairo.* PhD thesis, University of Cairo in Egypt.

Wafa, M. (1990) *Evolution Dynamics of Cairo.* PhD thesis, University of Cairo.

World Face Book (2007) *Report about Sustainability in Sudan.* Khartoum, pp. 7-12.

Electronic References

1 Sustainability examples from the USA and Canada
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!359126~!0&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Environment Agency. Sustainable Development Section.*
the Agency,
338.971 SUS
[Almondsbury] :
[1997].
x121040142

2. Environmental sustainability 1. SMG106.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!360916~!1&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
EXAM PAPERS
2000.

3. Environmental sustainability II. SMG107.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!361058~!2&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
EXAM PAPERS
2000.

4 European transport policy and sustainable mobility
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!362194~!3&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Banister, David, 1950-*
E. & F. N. Spon,
388.094 EUR
London :
2000.

5 Sustainability is the new buzz word in architecture. Can Ralph Erskine's architecture safeguard its future?.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!363310~!4&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Dillon, Keith A., University of Huddersfield. School of Design Technology.*
The University,
MA ARCH
Huddersfield :
2000.

6. Landscape and sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!365598~!5&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls

by/edited by *Benson, John F., Roe, Maggie H.*
E. & F. N. Spon,
712.01 LAN
London :
2000.
0419250808

7 Tourism, recreation, and sustainability : linking culture and the environment
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!370535~!6&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *McCool, Stephen F, Moisey, R. Neil*
CABI Pub,
338.4791 TOU
New York :
2001.
00062130

8. Tourism collaboration and partnerships : politics, practice, and sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!371269~!7&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Bramwell, Bill, Lane, Bernard, 1944-*
Channel View,
338.4791 TOU
Clevedon :
c2000.

9 Ecology, uncertainty and policy : managing ecosystems for sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!374517~!8&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Handmer, John W., Norton, Tony, Dovers, Stephen*
Pearson Education
333.95 ECO
New York,
2001.

10. Rough guide to sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!376529~!9&ri=2&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Edwards, Brian, 1944-, Hyett, Paul, Royal Institute of British Architects*
RIBA,
720.47 EDW
London :
2001.
1859461026

11 A chance to change : access, citizenship and sustainability in open learning

http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!297898~!0&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Fordham, Paul., Fox, John, Muzaale, Patrick, National Institute of Adult Continuing Education, Intermedia*
National Institute of Adult Continuing Education,
374.96762 FOR
Leicester :
1998.
1862010439

12 Environmental investment projects : what is being done to maintain sustainability?.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!305899~!1&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Kumar, Balvinder.*
BAAS
1997.
398737

13. Human settlements and planning for ecological sustainability : the case of Mexico City
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!306047~!2&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Pezzoli, Keith.*
MIT Press,
363.707097253 PEZ
Cambridge, Mass :
c1998.
UKM0000354

14. Dimensions of sustainability : architecture, form, technology, environment, culture.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!306699~!3&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Scott, Andrew*
E. & F. N. Spon,
720.47 DIM
London :
1998.
0419236201

15. A cultural development strategy for a firm wishing to maximise the sustainability behaviour of its workforce.

http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!308186~!4&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Jones, David Raymond., University of Huddersfield. School of Business.*
The University,
PhD
Huddersfield :
1998.

16 Education for sustainability : the best of Green teacher
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!313482~!5&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Randle, Damian.*
Green Teacher Co-operative,
333.707 EDU
Aberystwyth :
1997.

17. Tourism and sustainability in the Yunnan Great Rivers ICDP, China.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!317990~!6&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Cater, Erlet.*
Department of Geography, University of Reading,
338.479151 CAT
Reading :
1999.

18. Local sustainability : turning sustainable development into practical action in our communities : case studies, observations and lessons from the Leicester Environment City project and other pioneering initiatives
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!320763~!7&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Roberts, Ian, Few, Roger, Leicester Environment City Trust*
Environ,
333.7 LOC
Leicester :
1996.

19. Local sustainability : turning sustainable development into practical action in our communities : case studies, observations and lessons from the Leicester Environment City project and other pioneering initiatives / Summary.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!320766~!8&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Roberts, Ian, Few, Roger, Leicester Environment City Trust*
Environ,
333.7 LOC
Leicester :

1996.

20 Sustainability indicators: measuring the immeasurable?
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!321754~!9&ri=24&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Bell, Simon., Morse, Stephen, 1957-*
Earthscan,
333.72 BEL
London :
1998.
1853834971
.
21 The ecology of commerce : a declaration of sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!253720~!0&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Hawken, Paul.*
Phoenix,
658.408 HAW
London :
1995.

22 Agricultural sustainability, growth, and poverty alleviation : issues and policies : proceedings of the conference held from 23 to 27 September, 1991 in Feldafing, Germany
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!255377~!1&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Conference on Agricultural Sustainability, Growth, and Poverty Alleviation (23 to 27 September, 1991 : Feldafing, Germany)., Vosti, Stephen A., Reardon, Thomas, Von Urff, Winifred*
DSE,
338.1091724 CON
Feldafing, Germany :
1991.

23 Family planning programmed sustainability : a review of cost recovery approaches
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!255458~!2&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Seminar on Programmed Sustainability Trough Cost Recovery (21-25 October 1991 : Kuala Lumpar, Malaysia)., Ashford, Lori S., Bouzidi, Mohammed, International Planned Parenthood Federation*
IPPF,
613.94091724 SEM
London :
1992.

24 Environmental planning and sustainability

http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!265305~!3&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Evans, Bob, 1947-, Buckingham-Hatfield, Susan.*
John Wiley & Sons,
363.7 ENV
Chichester ; New York :
c1996.

25 Evaluation of the built environment for sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!265646~!4&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Brandon, Peter S., Bentivegna, V., Dècina Lombardi, Paola*
E. & F. N. Spon,
711.4 EVA
London :
1997.
0419219900

26 Local sustainability : managing and planning ecologically sound places
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!265696~!5&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Selman, Paul H.*
Chapman,
333.7 SEL
London :
1996.

27 Tourism and sustainability : new tourism in the third world
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!275786~!6&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Mowforth, Martin., Munt, Ian*
Routledge,
338.4791 MOW
London :
1997.
0415137640

28. The sustainability of social sector programs in India
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!280049~!7&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Hariharan, Githa, Bamberger, Michael, Economic Development Institute*
Economic Development Institute of The World Bank,
303.440954 SUS
[Washington, D.C.] :
1992.

29. Tourism and sustainability : from principles to practice
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!289049~!8&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Stabler, M. J.*
CAB International,
338.4791 TOU
New York :
1997.
97005265

30. The world's monetary system : toward stability and sustainability in the twenty-first century
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!293484~!9&ri=23&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Griesgraber, Jo Marie, Gunter, Bernhard G, 1965-*
Pluto Press,
332.152 WOR
London ; East Haven, CT :
1996.
0745310524

31. The green skyscraper : the basis for designing sustainable intensive buildings
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!330780~!1&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Yeang, Ken, 1948-*
Prestel,
720.47 YEA
New York :
1999.
98034625

32 .The green skyscraper : the basis for designing sustainable intensive buildings.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!336820~!2&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Yeang, Ken, 1948-*
Prestel ; Biblios,
Munich : Partridge Green :
1998.
3791319930
184p. :

33 .
Nachhaltige Höhe : Deutsche Messe AG Hannover Verwaltungsgebäude
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!346541~!3&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Bodenbach, Christof, Herzog, Thomas, 1941-*
Prestel,

725.23047209435954 NAC
Munich ; London :
2000.
3791322958
64p. :

34 Sustainable architecture in Japan : the green buildings of Nikken Sekkei
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!348371~!5&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Matsunari, Kazuo, Nakada, Yukiko, Ray-Jones, Anna*
Wiley-Academy,
720.47 SUS
Chichester :
c2000.
0471864579

35. Technology and place : sustainable architecture and the Blueprint Farm
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!379376~!6&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Moore, Steven A, 1945-*
University of Texas Press,
631.209764 MOO
Austin :
2001.
00010975

36 Construction ecology : nature as the basis for green buildings
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!380976~!7&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Kibert, Charles J., Sendzimir, Jan, Guy, G. Bradley*
Spon,
720.47 KIB
London :
2002.
2001034698

37 Sustainability at the cutting edge : emerging technologies for low energy buildings
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!407418~!8&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Smith, Peter F. 1930-*
Architectural,
720.47 SMI
Oxford :
2003.
0750656786

38 Buildings, culture & environment : informing local & global practices
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!411006~!9&ri=17&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Cole, Raymond, 1948-, Lorch, Richard*
Blackwell Pub,
720 BUI
Oxford, UK ; Malden, MA :
c2003.
2003001935

39. Building without borders : sustainable construction for the global village
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!435743~!1&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Kennedy, Joseph F.*
New Society,
720.47 BUI
Gabriola Island, B.C. :
c2004.
0865714819

40. Wind power in view : energy landscapes in a crowded world
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!442666~!2&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Pasqualetti, Martin J., 1945-, Gipe, Paul., Righter, Robert W.*
Academic,
333.92 WIN
San Diego, Calif. ; London :
2002.

41. Cities, people, planet : liveable cities for a sustainable world
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!443790~!3&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Girardet, Herbert*
Wiley-Academy,
307.1216 GIR
Chichester :
2004.
047086575X

42 Alternative construction : contemporary natural building methods
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!444001~!4&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Elizabeth, Lynne., Adams, Cassandra*
Wiley,
691 ALT
New York ; Chichester :

c2005.
0471719382

43. Continuous productive urban landscapes : designing urban agriculture for sustainable cities
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!445247~!5&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Viljoen, André., Bohn, Katrin., Howe, J.*
Architectural,
307.1216 VIL
Amsterdam ; London :
2005.
0750655437

44. Building with straw : design and technology of a sustainable architecture
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!451937~!6&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Minke, Gernot., Mahlke, Friedemann.*
Birkhäuser,
693.997 MIN
Basel :
c2005.

45. Sustainable architectures : cultures and natures in Europe and North America
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!451938~!7&ri=14&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Guy, Simon., Moore, Steven A.*
Spon,
720.47 SUS
New York ; London :
2005.

46. Sustainable construction CPD. Electrical installations.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!425539~!0&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
Gaia Research,
720.47 SUS
Edinburgh :
c2003.

47 Sustainable construction CPD. Low impact construction.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!425540~!1&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
Gaia Research,
720.47 SUS
Edinburgh :
c2003.

48. Sustainable construction CPD. Lighting and daylighting.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!425541~!2&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
Gaia Research,
720.47 SUS
Edinburgh :
c2003.

49. Towards a sustainable eco-tech architecture: can eco-tech architecture provide a solution to the problem of increasing urban un-sustainability?.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!427235~!3&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Ruthven, Ian.*
The University,
DIP ARCH
Huddersfield :
2003.
774376
.
50 An urban approach to climate-sensitive design : strategies for the tropics
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!428377~!5&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Emmanuel, M. Rohinton, 1962-*
Spon,
720.470913 EMM
London :
2005.
0415334101

51. Eco-refurbishment : a guide to saving and producing energy in the home
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!428383~!6&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Smith, Peter F. 1930-*
Architectural,
720.472 SMI
Oxford :
2004.
0750659734

52 Ecological design. inventing the future.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!431051~!7&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
Filmwest Associates,
720.47 ECO
Kelowna, BC. :

[1995].
Videocassette (64 min) :

53 Sustainable architecture.
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!434579~!9&ri=12&aspect=basic_search&menu=search&source=~!horizon&profile=cls
San Luis Video,
720.47 SUS
Los Osos, Calif. :
[n.d.].
Videocassette :

54 Sustainable architecture and urbanism : Concepts, Technologies, Examples
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!406247~!1&ri=8&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Gauzin-Müller, Dominique.*
Birkhäuser ; Momenta,
720.47094 GAU
Basel : London :
2002.
.

55 Appropriate sustainabilities : new ways in French architecture = Innovations durables : une autre architecture française
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!411625~!9&ri=8&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Emery, Marc E. Albert, Ravanel, Luciana*
Birkhäuser,
720.470944 APP
Basel :
2002.
3764367385

56 Design for sustainability : a sourcebook of integrated eco-logical solutions
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!389206~!6&ri=6&aspect=basic_search&menu=search&source=~!horizon&profile=clsby/edited by *Birkeland, Janis.*
Earthscan,
720.47 BIR
London :
2002.

57. Architecture in a climate of change : a guide to sustainable design
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!375993~!4&ri=5&aspect=basic_search&menu=search&source=~!horizon&profile=clsby/edited by *Smith, Peter F. 1930-*
Architectural Press,
720.47 SMI
Oxford :

2001.

58 Sustainable architecture in Japan : the green buildings of Nikken Sekkei
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!348371~!6&ri=3&aspect=basic_search&menu=search&source=~!horizon&profile=clsby/edited by *Matsunari, Kazuo, Nakada, Yukiko, Ray-Jones, Anna*
Wiley-Academy,
720.47 SUS
Chichester :
c2000.
0471864579

59. Landscape and sustainability
http://webcat.hud.ac.uk/ipac20/ipac.jsp?uri=full=3100008~!365598~!9&ri=3&aspect=basic_search&menu=search&source=~!horizon&profile=cls
by/edited by *Benson, John F., Roe, Maggie H.* E. & F. N. Spon, 712.01 LAN
London: 2000.
0419250808

Websites

- Building, R.E.E.A.M. (2006) *Building Research Establishment Environmental Assessment Method* [online] Available at: <http://products.bre.co.uk/breem/> [Accessed 15 July 2005, 20 January 2007 and 18 June 2009].
- American, I.A. (2007) *Committee on the Environment* [online] Available at: <http://www.aia.org/cote/ > [Accessed 24 March 2006].
- Advanced, B. (2004) *Wide Range of Technologies and Products to Improve Energy* [online] Available at:<http:www.advancedbuildings.org/ > [Accessed 5May 2007].
- Earth, S. (2002) *earth Submit* [online] Available at: <http://www.earthsummit2002.org> [Accessed 21 Sept.2007].
- Institute, S.T.P. (2003) *Directory of Policy Journals in Transport, Urban Planning and Sustainability* [online] Available at: <http://wwwispt.murdoch.edu.au/research/journal/> [Accessed 30 Sept. 2007].
- ODPM. (2005) *Planning Policy Guidance* [online] Available at: <http://www.planning.odpm.gov.uk/ppg/index.html > [Accessed 10 Oct. 2007].
- Online, WSSD. (September 2002 World Summit) *Sustainable Development, Johannesburg* [online] Available at: < http://www.wssd-and-civil-society.org> [Accessed 15 Oct. 2007].
- UK. Government, *Sustainable Development* [online] Available at: < http://www.sustainable-development.gov.uk> [Accessed 25 Nov. 2oo7].
- Sustainable D. (2007) *Sustainable Development Searchable Dedicated Library Collection / Archive* [online] Available at: <http://brad.ac.uk/library/elecinfo/bdsc.htm> [Accessed 10 Dec. 2007].
- UK Environment, *Digest of Green Issues* [online] Available at: < http;//www.ukenvironment.org> [Accessed 10 Jan. 2008].
- Sustainable, D.C. (2006) *Sustainable Development Commission* [online] Available at: <http://www.sd-commission.gov.uk > [Accessed 30 Jan. 2008].
- Sustainability, P.N. (2006) *Sustainability Practitioners Network* [online] Available at: < http://communities.msn/com/SPNUK/join?iid= > [Accessed 20 Feb. 2008].

- UK Government, *Sustainable Development Discussion Forum* [online] Available at: < http://sdu.bgsportal.com/discussion/index.asp > [Accessed 10 March 2008].
- Royal, T. P. I. (2007) *Sustainable Development Resources* [online] Available at: < http://www.rtpi.org.uk/resources/sustainable/ > [Accessed 10 April 2008].
- Sustainable, W. (2007) *NGOs in Wales Promoting Sustainable Development* [online] Available at: < http://www.sustainablewales.org.uk > [Accessed 25 May 2008].
- Evolve, *Environmental Management and Sustainable Development Issues* [online] Available at: < http://www.e-volve.org.uk > [Accessed 15 June 2008].
- Transport, R.L. (2007) *Sustainability for SEA* [online] Available at: < http://www.sea-inf.net > [Accessed 21 July 2008].
- Centre .T. *Eco Center's Activities, Projects and publications* [online] Available at: < http://www.cat.org.uk/ > [Accessed 10 Sept. 2008].
- British, U.R.A. (2007) *British Urban Regeneration Association* [online] Available at: < http://www.bura.org.uk/ > [Accessed 30 Sept 2008].
- Ecological, D.A. (2007) *Ecological Design Association* [online] Available at: < http://www.edaweb.org/ > [Accessed 21 Oct. 2008].
- Green, A. *Architectural Record for Green Architecture* [online] Available at: < http://archrecord.construction.com/features/green/ > [Accessed 10 Nov. 2008].
- European, C. *European Commission for Transport, Energy, Environment and Transport* [online] Available at: < http://europa.eu.int/comm/dgs/energy-transport/ , http://.europa.eu.int/comm/energy/ [Accessed 15 Dec. 2008].
- Environmental, D.C. *Products, Techniques, Resources and Support* [online] Available at: < http://www.edcmag.com/ > [Accessed 20 Jan. 2009].
- Building, E.E.S. *Assessment Method for Environmental and Economic Sustainability version 3.0.* [online] Available at: < http://www.bfrl.nist.gov/oae/software/bees.html > [Accessed 21 Feb. 2009].
- Association, E.C.B. *Association Environmentally Conscious Builders* [online] Available at: < http://www.aecb.net/ > [Accessed 17 March 2009].
- US environmental, P.A. *Community Based environmental Protection* [online] Available at: < http://www.epa.gov/ecocommunity/ > [Accessed 24 March 2009].

- Global, R.I. (2006) *Institution that is involved in developing and providing information about sustainability reporting guidelines* [online] Available at: < http://www.globalreporting.org/ > [Accessed 15 April 2009].
- International, I.S.D. (2008) *Aims to Advance Sustainable Development by Developing Policy Recommendations* [online] Available at: < http://www.iisd.org/ > [Accessed 5 May 2009].
- Santa, M. S.C.P. (2008) *Policy, Community Goals and City Plans* [online] Available at: < http://www.ci.santa-monica.ca.us/environment/policy/ > [Accessed 12 June 2009].
- Sustainability, N. (2008) *Activities and Services of Sustainable Development Consultancy* [online] Available at: < http://www.sustainability.com/ > [Accessed 10 July 2009].
- Sustainable, C. (2008) *European Sustainable Cities Project and Campaign* [online] Available at: < http://www.sustainable-cities.org/ > [Accessed 24 August 2009].
- World, C. U. (2008) *Partnership Organization Supporting Nature, Ecology, Conservation and Sustainability* [online] Available at: < http://www.iucn.org/ > [Accessed 15 Sept. 2009].

.

Abbreviations

SDNRF	Sustainable Development of the Nile River Front
SD	Sustainable Development
NBI	National Basin Initiative
EIA	Environmental Impact Assessment
SEA	Strategic Environmental Assessment
BAR	Building Authorities Regulations
BR	Building Regulations
CBD	Central Business District
NRS	Nile River Shores
BNR	Blue Nile River
WNR	White Nile River
MNR	Main Nile River
WL	Water Level
RH	Relative Humidity
RHS	River Habitat Survey
URS	Urban River Survey
ESI	Environmental Sustainable Indicators
PLS	Plan Led System
BSM	Bank Stabilization Method
PDP	Proposed Development Plan
SI	Social Indicators
PLS	Plan Led System Zones
GQA	General Quality Assessment
Ag	Agriculture
FO	Forest
PA	Pasture
OW	Open Water
WE	Wetland
BA	Bare
UNEP	United Nations Environmental Programme

DNRFGC	Development of the Nile River Front at Greater Khartoum
JICA	Japanese International Corporation Association
PDP	Proposed Development Plan
PPG	Planning Policy Guidance
PPS	Planning Policy Statements
RSS	Regional Spatial Strategy
LDF	Local Development Framework
LDS	Local Development Scheme
LDDs	Local Development Documents
USD	United States Dollars
SD	Sudanese Dinnars
E	East
W	West
S	South
N	North
GDP	Gross Domestic Product
MIS	Ministry of Irrigation in Sudan
WB	World Bank
EU	European Union
ADB	African Development Bank
IDB	Islamic Development Bank
AB	Arab Bank
AHD	Aswan High Dam
NGOs	Non Governmental Organizations
KSWC	Khartoum State Water Corporation
KSSC	Khartoum State Sewerage Corporation
BS	British Standard
CP	Code of Practice
CPA	Comprehensive Peace Agreement
SPLM	Sudan People’s Liberation Army
NCP	National Congress Party

MFNE	Ministry of Finance and National Economic
PH	Hydrogen Concentration
EC	Electric Conductivity
TDS	Total Dissolved Solids
HCO^3	Bicarbonate
T ALK	Total Alkalinity
CI	Chloride
Na+	Sodium
OG	Oil and Grease
DO	Dissolved Oxygen
NO^2	Nitrates
COD	Chemical Oxygen Demand
NA	Not Analyzed
MW	Mega Watts
Km	Kilometer
m	Meter
Cm	Centimeter
mm	Millimeter